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THE

OCCURRENCE AND DISTRIBUTION

OF

CORUNDUM IN THE UNITED STATES

BY

JOSEPH HYDE PRATT

WASHINGTON
GOVERNMENT PRINTING OFFICE
1901

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OCCURRENCE AND DISTRIBUTION OF CORUNDUM IN THE UNITED STATES.

By Joseph Hyde Pratt.

INTRODUCTION.

In obtaining data for this paper many corundum localities were visited, especially those that were thought to carry the mineral in commercial quantity. Although all the occurrences of corundum can not be described in detail, they are all mentioned in the tabulated list of localities, page 79.

Considerable activity in corundum mining has sprung up within the last few years, and several new occurrences of corundum in quantity have been brought to light, those of special note being in Ontario, Canada, where the corundum occurs in a syenite, and in North Carolina and Georgia, where it occurs in a gneiss or a quartz-schist.

The corundum localities in the United States are, with the exception of those in Montana, Colorado, and California, limited to the Appalachian region, the mineral having been found at various points throughout nearly its entire length. The mining of corundum has been, however, confined to a narrow section of the southern portion of that region, i. e., to northeastern Georgia and southwestern North Carolina, with the exception of the emery mines at Chester, Mass.

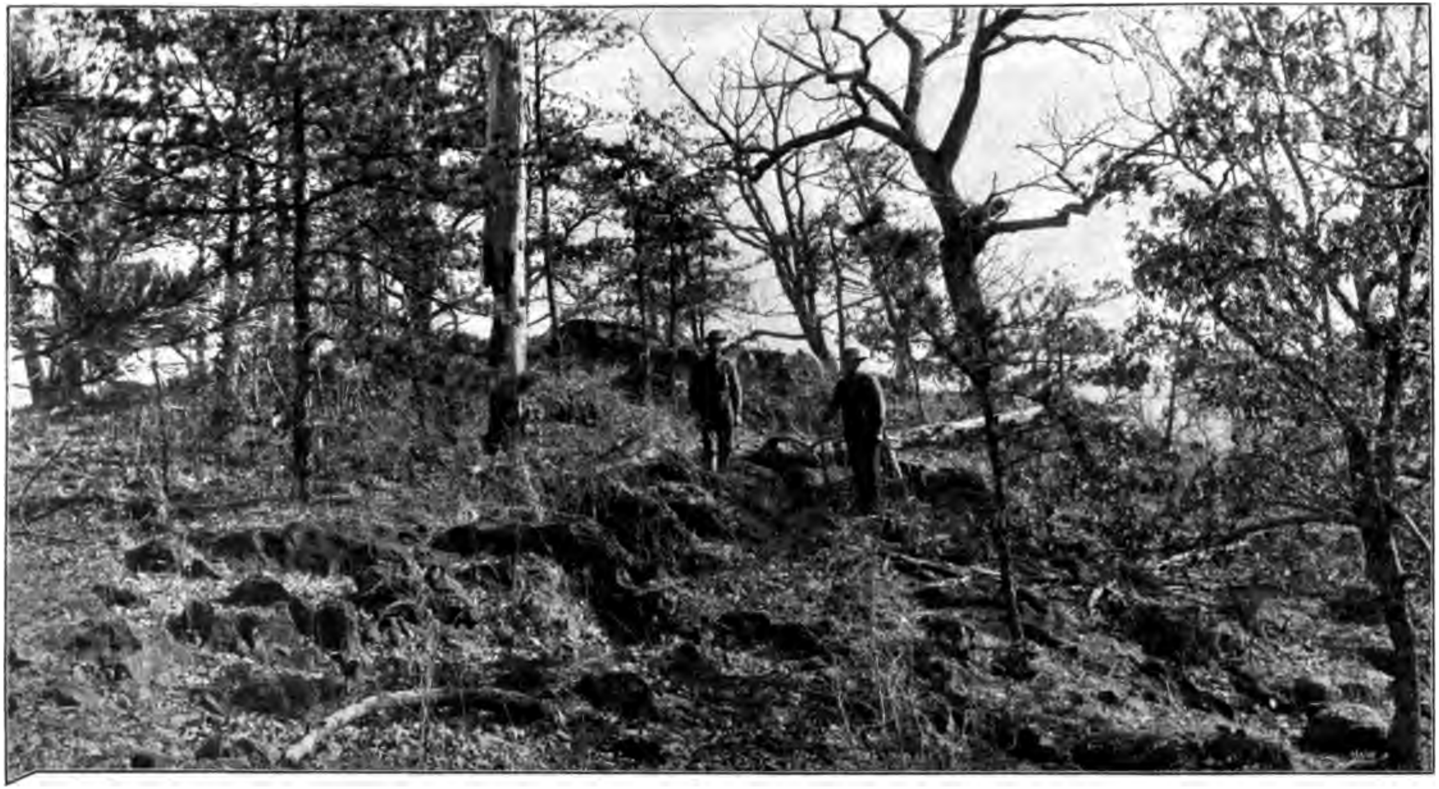
Often a distinction is made between emery and corundum, many persons not recognizing emery as a variety of corundum. There are three names in constant use to designate the varieties of corundum: (1) Sapphire, which includes all corundums, of whatever color, that are transparent to semitransparent; (2) corundum, including the translucent to opaque varieties of all colors; (3) emery, which is a mechanical admixture of corundum and magnetite or hematite. The last two varieties are those used in the arts for abrasive purposes, emery being used in very much larger quantities than corundum. It is of course the presence of corundum in the emery that gives to it its abrasive qualities and makes it of commercial value, and the abrasive efficiency of emeries varies according to the percentage of corundum they contain.

Any corundum that is transparent is included under the head of sapphires, although many of these have distinct names in the gem trade. The blue sapphire is known as the oriental sapphire, the red sapphire as the oriental ruby, the green sapphire as the oriental emerald, the yellow sapphire as the oriental topaz, and the purple sapphire as the oriental amethyst. There are also pink and white sapphires. The corundum gem or sapphire localities are usually distinct from the corundum localities, although very handsome gems have been found where the corundum was mined for abrasive purposes, notably at the Corundum Hill mine, Cullasagee, N. C.

Corundum as it is mined for abrasive purposes occurs as (1) sand, (2) crystal, or (3) gravel and block corundum. Sometimes all three types are found in the same deposit. The sand corundum consists of small grains or fragments of the mineral scattered through the vein. The crystal corundum consists of crystals up to 3 inches in length. Often these crystals have parting planes so thoroughly developed that, in crushing, the corundum breaks up into regular rhombohedrons, this breaking continuing to even the finer sizes and causing the grains of corundum to crumble when in use. This persistent regular breaking of the corundum destroys its cutting efficiency, for it is the irregular fracture that produces the best cutting edge. The block variety often occurs in masses of almost pure corundum from 10 to 1,000 pounds in weight. Again it occurs in large masses intimately associated with hornblende, feldspar, etc., making a rock which is tough and is difficult to work. Frequently the only way to break the masses is to build fires over them and then suddenly cool them by pouring water upon them. The parting planes are at times very noticeable in the block corundum, and are, as in the crystal corundum, detrimental to the commercial product. The parting planes are not lines of cleavage, but are planes developed in the mineral by synthetic twinning, usually parallel to the unit rhombohedron.

It is the hardness of corundum that makes it of so great value as an abrasive. Next to the diamond it is the hardest mineral known, having a hardness of 9, while the diamond has a hardness of 10. Garnet, which is sometimes used as an abrasive, has a hardness of but 7 to 7.5. Corundum varies slightly in hardness; the sapphire varieties are generally considered the hardest, and of these the blue stands at the head. Some corundum has been observed that was readily scratched with a knife, as that from Acworth, Ga. The hardness of a corundum is often misjudged because, when made into a wheel, it does not cut so well as another, when in reality the degree of hardness may be the same in both cases, but the cutting efficiency of one surpasses that of the other.

The theoretical composition of corundum is alumina (Al_2O_3); but with one or two exceptions all corundums that have been examined vary from this by containing a small percentage of other constituents, principally silica (SiO_2), water (H_2O), and ferric oxide (Fe_2O_3). Nearly all corundums contain water, the amount varying from a trace to 2 per cent or more. The amount of silica and ferric oxide varies also, some corundums containing neither of these constituents and some



OUTCROP OF PERIDOTITE AT BUCK CREEK, CLAY COUNTY, N. C.

containing as much as 5 per cent of one or the other. The purest forms of corundum that have been analyzed are the sapphire or gem varieties, which sometimes show over 99.5 per cent of alumina.

All corundums do not behave alike when heated to the high temperature necessary for the manufacture of vitrified wheels. While most corundums can, if properly cleaned, be used in the manufacture of these wheels, some will, when heated, crumble to a powder. It is, therefore, very essential, before beginning to mine a corundum deposit, to thoroughly test the ore and ascertain its adaptability to the manufacture of vitrified and other wheels.

MODES OF OCCURRENCE OF CORUNDUM.

Corundum was formerly regarded as occurring sparingly in nature, and in only a few types of rocks, but it is now known to occur rather widely, and instead of being in quantity in the basic magnesian or peridotite rocks only, it has been found in abundance in syenites, in gneisses, and in schists. Although occurring in many of the crystalline rocks, it has been observed as a rock constituent in only a few of them. In some cases it is an original constituent of the rock, and in other cases it has been formed later, during the process of metamorphism.

In the United States corundum is known to occur in the following rocks: In peridotite (dunite and saxonite), in biotite contact on saxonite, in enstatite, in serpentine, in chlorite-schist, in amphibolite, in norite, in basic minette, in andesite, in syenite, in amphibole-schist, in gneiss, in mica-schist, in limestone, and in cyanite. These modes of occurrence are described below in the order in which they are mentioned.

CORUNDUM IN PERIDOTITES.

Extending from Tallapoosa County in east-central Alabama to Trenton, N. J., there is a narrow belt which contains disconnected outcrops of peridotite rocks; north of New Jersey (in New York, Connecticut, Massachusetts, New Hampshire, and Maine) the outcrops are fewer and do not form a continuous belt. It is in the southern portion of this belt that these rocks have reached their greatest development, in some localities outcropping over an area of several hundred acres. In North Carolina and in the more southern portion of the belt the prevailing type of the rock is dunite, while in the northern portion the secondary rocks, serpentine and talc, are prominent. Pl. I is a reproduction of a photograph of an outcrop of dunite at Buck Creek, Clay County, N. C.

Throughout nearly the entire southern portion of the belt the peridotite rocks show a freshness to almost the surface of the exposures, and there are few localities where there is any considerable area of peridotite entirely altered to serpentine. Under the microscope thin sections of the dunite show an alteration to serpentine between the particles of dunite. These peridotite rocks have been shown to be of igneous origin.[1] The blunt lenticular form in which they are found would be difficult to associate with any origin but that of an intruded igneous mass, which would also account for the apophyses that have been observed extending into the inclosing gneiss. At Webster, Jackson County, N. C., a large block of gneiss is completely inclosed by the peridotites in such a manner as could be attributed only to the intrusion of the latter while in a molten condition. The line of separation of the peridotites and the gneisses is always sharp, and there is no transitional zone from the acid gneiss to the basic peridotite. Under the microscope the latter rock shows the granular structure characteristic of plutonic origin, the grains fitting perfectly into one another without cementing material.

Associated with all these peridotites is the mineral chromite, which occurs as disseminated particles near the borders of the lenticular masses of the peridotites. There is very little carbon found associated with these rocks, and what has been observed is unquestionably of secondary origin.

Until recently the common occurrence of corundum (not including emery), and the occurrence in which the mineral had been found in commercial quantity, was in association with these basic magnesian rocks, peridotites, principally dunite. The country rock that is commonly in contact with the peridotite is a hornblende-gneiss, but these peridotite formations have also been found in contact with a biotite-gneiss and with a mica-schist. Where the country rock is a gneiss it is usually considerably decomposed near the contact, and, while retaining the appearance of the unaltered rock, it readily crumbles to pieces when handled. The peridotite is also more or less altered, the change being usually to serpentine.

The corundum is not an accessory mineral in these peridotites, but is either concentrated near the contact of the peridotite with the other country rocks or in pockets within the peridotite formation. A series of alteration products has been developed in this contact zone, so that the corundum is not found in direct contact with the peridotite, but is separated by intermediate zones of chlorite, enstatite, etc. Chlorite and vermiculite are usually developed between the corundum and the gneiss. For convenience, the occurrences of the corundum in these alteration products between the peridotite and the gneiss are designated contact veins, and those wholly within the peridotite dunite veins.

In a cross section of a contact vein extending from the gneiss to the peridotite (dunite) the following sequence is often observed:

a. Gneiss, hornblendic or micaceous, apparently unaltered.

b. Gneiss with same general appearance as *a*, but so decayed that the particles readily separate from one another.

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[1] Elisha Mitchell Sci. Soc. Jour., Part II, 1895, p. 35, and Am. Jour. Sci., 4th series, Vol. VI, *1898, p. 50.*

c. Yellowish vermiculites, varying considerably in thickness, the maximum being 6 to 8 inches; in places absent, so that *b* comes directly in contact with *d*; where present, *c* often merges into *d*.

d. Green chlorite, varying in thickness much like *c*, and in places absent.

e. Chlorite and corundum, sometimes with a little vermiculite. In places this mass may be largely corundum, and it is what is called the "corundum vein," varying in thickness from a few inches to 12 or 15 feet.

f. Green chlorite; so far as observed always present, and varying in width from 1 to 12 inches.

g. Enstatite; in places hard and compact, and in widths of several feet; usually merges into *h*.

h. Talcose rock, usually fibrous, varying in thickness from a few inches to several feet.

j. Dunite, more or less altered, friable, and stained with ferric oxide.

k. Dunite, apparently unaltered, quite extensive.

Between *h* and *j* a seam of yellowish clay (*i*) is sometimes observed which often contains a narrow seam or fragments of chalcedony.

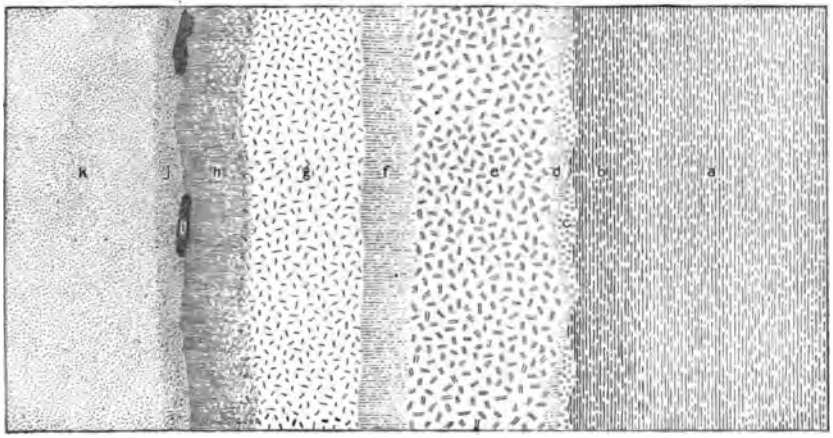

FIG. 1.—Ideal cross section of a corundum contact vein at the Corundum Hill mine, North Carolina. *a*, fresh and unaltered gneiss; *b*, decayed and unaltered gneiss; *c*, vermiculites; *d*, green chlorite; *e*, corundum-bearing zone; *f*, green chlorite; *g*, enstatite; *h*, talcose rock; *i*, clay; *j*, altered dunite; *k*, unaltered dunite.

From what could be learned by actual observation and inquiry among the miners, *c* and *d* are sometimes absent, and when this is the case, *e*, a mixture of chlorite, vermiculite, and corundum, is seemingly in direct contact with *b*. The chlorite, however, on the dunite side of the section is constant. The thickness of the several zones (*a*, *b*, *c*, etc.) in such sections varies greatly at different places, and the distance across the sections may be said to vary at different points, even in the same region, from a few feet to 30 or 40 feet. The accompanying diagram (fig. 1) represents the cross section of a contact vein observed at the Corundum Hill mine, Cullasagee, Macon County, N. C.

In the diagram *a* represents gneiss, apparently fresh and unaltered, passing into *b*, which has somewhat the appearance of the unaltered gneiss, but is so decayed that the particles readily separate from one another; *c* represents a narrow zone of vermiculites that is sometimes entirely lacking; *d*, a green chlorite (clinochlore) partially decomposed and forming the vermiculites of *c*; *e*, the corundum-bearing zone, a mass of the green chlorite with crystals and fragments of corundum disseminated through it; *f*, another zone of the green chlorite; *g*, a mass of grayish, interlocking, crystalline sheaves of enstatite that merge into *h*; *h*, a fibrous talcose rock which passes into *j*; *j*, an altered dunite that is somewhat friable and stained with ferric oxide; *k*, a hard and apparently unaltered dunite. Between *h* and *j* is a mass of soft, yellowish clay (*i*) containing fragments of chalcedony.

The line of contact between the zone of alteration products and the gneiss was very sharp and distinct in all the contact veins examined. The minerals developed between the corundum-bearing zone and the dunite are in great abundance and differ from those between that zone and the gneiss.

In a cross section of a dunite vein at a shaft near the southern part of Corundum Hill, in a distance of from 20 to 25 feet, the following has been observed:

1. Dunite, hard and apparently unaltered.
2. Dunite, somewhat friable and discolored, passing into 3.
3. Talcose rock, fibrous, merging into 4.
4. Enstatite, grayish and somewhat fibrous.
5. Green chlorite, 6 to 15 inches in width.
6. Green chlorite, corundum, and spinel, 6 to 8 feet wide.
7. Chlorite, same as 5.
8. Enstatite, same as 4.
9. Talcose rock, same as 3.
10. Dunite, same as 2.
11. Dunite, same as 1.

The similarity of the two parts of the vein separated by the corundum zone, as already described and as illustrated in fig. 2, is very apparent.

In fig. 2, 1 and 11 represent the apparently unaltered dunite; 2 and 10 represent dunite somewhat friable and stained and passing into 3 and 9—a fibrous talcose rock, often carrying a green actinolite and some green chlorite; 4 and 8 represent a grayish, rather fibrous enstatite rock, which merges into 3 and 9; 5 and 7 represent a green chlorite, which passes into 6—a mass of chlorite, corundum, and spinel.

Although the section just described is a special case, it was observed that all of the dunite veins had the same character on both sides of the corundum-bearing zone. As has been already stated, either a talcose or a serpentine rock may be the limit of the cross section. In one of the dunite veins at Corundum Hill near the west end of the outcrop, the zone of corundum, chlorite, and vermiculites is in direct contact, both on the hanging and on the foot wall, with a serpentine rock. This zone is divided—in one place almost pinched out—by a mass of serpentine.

At all of the corundum localities examined a careful search has been made to find the corundum directly surrounded by the peridotite, but it has been thus observed at only one locality—the Egypt mine, on the western slope of the Sampson Mountains, in Yancey County, N. C. The few specimens obtained were collected by Mr. U. S. Hayes, who developed the corundum property in that section. One specimen shows a prismatic crystal of the corundum surrounded by a granular peridotite (dunite), but with none of the chlorite minerals which usually intervene. The dunite is not quite fresh, but is stained a yellowish brown by iron oxide and is rather friable. On the basal surfaces of the corundum a little muscovite is developed. This has been observed on corundum from other localities.

Spinel has been found at a number of the corundum veins, and in a few cases it is very intimately associated with the corundum. At the Carter mine, near Democrat, Buncombe County, N. C., the corundum is found, in masses of a white and pink color, intergrown with a greenish-black spinel. The masses of corundum and spinel are partially surrounded by a deep-green chlorite, which has also been developed in places between the corundum and the spinel, although this contact of the corundum and the spinel is usually very sharp and distinct. A massive, coarsely to finely granular spinel is found at the Corundum Hill mine, Macon County, N. C., which has disseminated through it small grains and fragments of pink and white corundum.

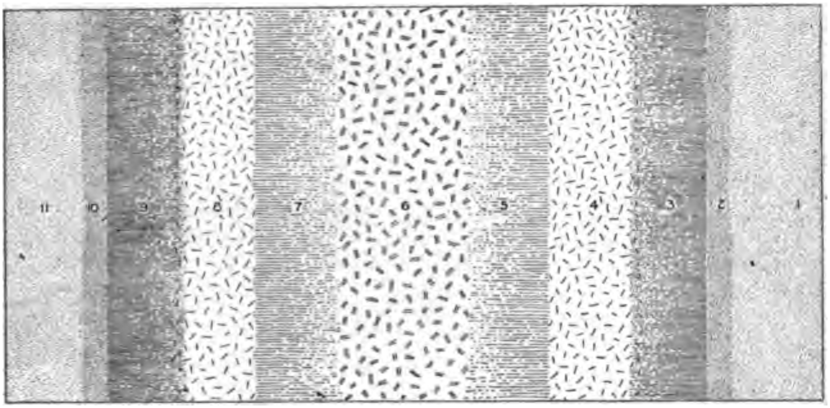

FIG. 2.—Ideal cross section of a corundum-dunite vein at the Corundum Hill mine, Macon County, N. C. 1, hard and unaltered dunite; 2, friable and discolored dunite; 3, talcose rock; 4, enstatite; 5, green chlorite; 6, green chlorite, corundum, and spinel; 7, green chlorite; 8, enstatite; 9, talcose rock; 10, friable and discolored dunite; 11, dunite.

The mineral chromite, which has always been found associated with these peridotite rocks, occurs sparingly in many of the corundum veins. It is a well-observed fact[1] that where there is any quantity of corundum found in the peridotite rocks there is a scarcity of chromite, and where there is a large quantity of chromite there is a scarcity of corundum.

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[1] Am. Inst. Min. Eng., Vol. XXIX, 1899; February meeting.

In a recent paper[1] I have discussed the origin of the corundum in the peridotite rocks, and have accepted the theory that the corundum was held in solution in the molten mass of the peridotite when it was intruded into the country rock, and that as the mass began to cool it was among the first minerals to separate. In these molten magmas the more basic minerals, corundum and spinel, would be the first to separate, and this separation would take place along the outer border of the mass, for there it would first cool. Convection currents would then tend to bring into this outer zone a new supply of material carrying alumina, and when this zone was reached crystallization would take place and the alumina would be deposited as corundum.

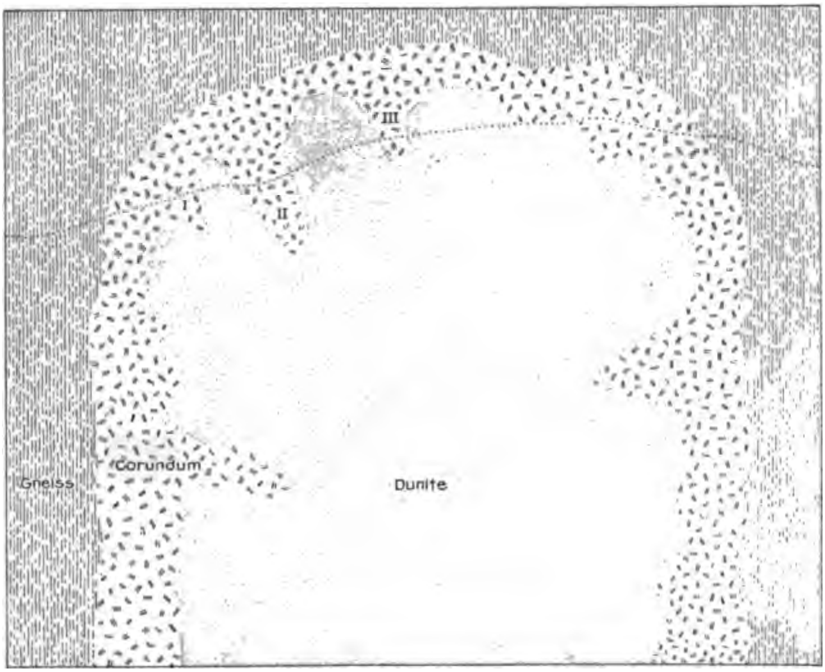

FIG. 3.—Ideal vertical cross section of a mass of peridotite soon after its intrusion in gneiss. The corundum zone is greatly exaggerated.

Fig. 3 represents an ideal appearance of a vertical cross section of a mass of dunite holding corundum in solution, soon after its intrusion into a gneiss. In this figure the corundum zone has been greatly exaggerated, in order to illustrate better the cross section. The corundum would be concentrated toward the borders of the dunite, and would make a sharp and nearly regular contact with the gneiss. The contact with the dunite would be in some places sharp and regular and in other places very irregular, and masses of the corundum would penetrate the dunite. In some cases there would be a somewhat gradual transition from the corundum to the peridotite, as represented in fig. 4. The rapid erosion to which rocks in a mountain region are subjected would readily wear them down to their present condition, represented by the dotted lines in fig. 3.

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[1] Am. Jour. Sci., 4th series, Vol. VI, 1898, p. 49.

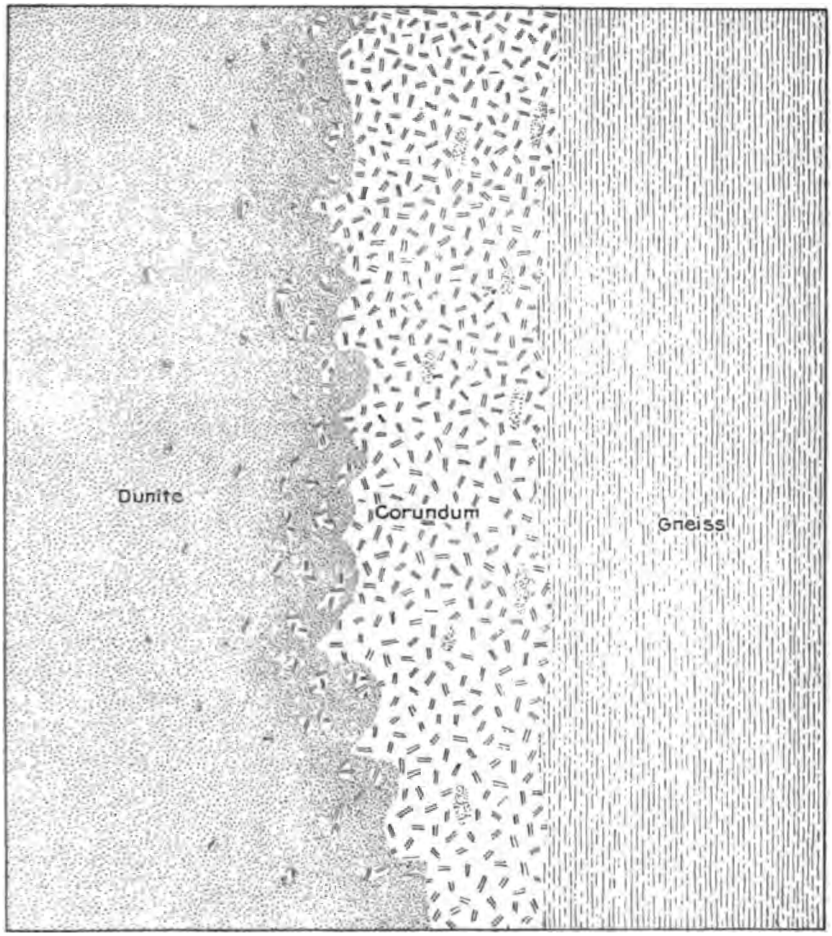

FIG. 4.—Ideal vertical cross section showing a somewhat gradual transition from corundum to peridotite.

The corundum veins, I, II, and III, in fig. 3, which at the present time have no connection with one another, but are each separate and distinct, were at the time of their formation part of the corundum concentrated along the border of the dunite. Some of these veins would soon be worked out, while others might be explored for a hundred or more feet without any apparent change in their width.

The most important observations leading to the adoption of this theory are: The occurrence of the corundum surrounded by granular dunite and also by serpentine; its occurrence with and surrounded by spinel; the sharp contact between the gneiss and the alteration products of the contact vein; the development, on both sides of a corundum vein penetrating dunite, of the same sequence of alteration products, which are almost identical with those on the dunite side of a contact vein; the usual narrowing and pinching of the dunite veins, the trend of which is toward the center of the mass of peridotite, while the contact vein seems to extend down indefinitely.

At a number of the corundum veins in these peridotite rocks, feldspar, which is undoubtedly one of the original minerals of the rock and not a secondary product, is found associated with the corundum. There is a marked difference in the associated minerals when the feldspar is present; the chlorite is not so thoroughly developed, and enstatite is not so common, while margarite is rather abundant and zoisite is not uncommon. These last two minerals are rarely met with free from feldspar in the corundum veins.

The separation of alumina from these peridotite magmas has given rise to some interesting problems, which I have treated in a paper[1] published a short time ago. A summary of the conclusions reached is given here, as they bear directly upon the occurrence of the associated minerals, spinel, chromite, and feldspar, in a corundum vein.

From what has been observed in nature and from the experiments that have been made in the laboratory, it seems that the separation of alumina as corundum from molten magmas is dependent upon the composition of the chemical compounds that are the basis of the magma, upon the oxides that are dissolved with the alumina in the magma, and upon the amount of alumina itself.

1. When the magma is composed of a magnesium silicate without excess of magnesia, all the alumina held by such a magma will separate as corundum.

2. Where there is an excess of magnesia in the magma just described, it will unite with a portion of the alumina to form spinel, and the rest of the alumina will separate as corundum.

3. Where there is chromic oxide present in a magma composed essentially of magnesium silicate (as the peridotite rocks), and only a very little alumina and magnesia are present, these, uniting, separate with chromic oxide to form the mineral chromite, and no corundum or spinel is formed.

4. When peridotite magmas contain, besides the alumina, oxides of the alkalies and alkali earths, as soda, potash, and lime, a portion of

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[1] Am. Jour. Sci., 4th series, Vol. VIII, 1899, p. 227.

the alumina is used in uniting with these oxides and with silica to form feldspar.

5. There is a strong tendency for the alumina to unite with the alkali and the alkali-earth oxides to form double silicates like feldspars, whether such silicates form the chief minerals of the resulting rock or are present in relatively small amount. There is, however, little tendency for the alumina to unite with magnesia to form double silicates when the magma is a magnesium silicate.

CORUNDUM IN BIOTITE, CONTACT ON SAXONITE.

At the asbestos quarry near Pelham, Mass., there is a large lens of the igneous saxonite variety of the peridotite rocks penetrating the acid gneiss of the country. The saxonite is very much altered to a depth of 3 to 12 feet, when the hard nearly fresh rock is encountered, which is of a dull-black color and is made up of grains of olivine and the orthorhombic pyroxene, bronzite. The black color of the rock is due to disseminated particles of chromite and magnetite. Part of the magnetite may be due to the alteration of the grains of olivine, similar to that observed in the dunites of North Carolina, where, at the beginning of its alteration, there is a deposition of magnetite in fine grains, which forms a network of black lines often outlining the grains of olivine.

Professor Emerson has made a petrographical examination of this rock and describes it as follows:[1]

> This is a very fresh mixture of olivine and enstatite, both dusted through with black ore, largely chromite. It is a dull-black rock of very great toughness. The olivine grains have often many crystalline faces. The enstatite is in rare, small plates, with parallel sides and irregular ends, and with a fine wavy lamination, which is often marked by lines of black ore, generally concentrated in some part of the plate, especially the center. Although nearly colorless or pale bronzy in common light, it has marked pleochroism. It is plainly rhombic, and grades into the asbestiform decomposition product in veins running through the section.

None of the anthophyllite that is so abundant in the decomposed portion of the saxonite were observed in the fresh rock.

From the fresh rock to the surface and the contact with the gneiss the saxonite is more or less completely altered, and penetrating through this there is a network of veins of anthophyllite, which are more or less asbestiform. These veins vary in width from very thin seams to 8 inches, with some that are very much wider, from which fibrous masses have been obtained 20 to 30 inches long. It is these veins of fibrous anthophyllite that constitute the asbestos quarry of Pelham.

The saxonite is separated from the gneiss by a band of bronze-colored biotite, usually 4 to 8 inches thick, but in places reaching a thickness of 4 feet. In this wider portion there are nodules or imperfect crystals of corundum of a grayish color mottled with blue.

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[1] Mon. U. S. Geol. Survey Vol. XXIX, p. 52.

These are often wrapped with chlorite. Nodules of a black-green hornblende and an emerald-green actinolite are also found in the biotite. There has been no great quantity of the corundum found.

This zone of biotite is probably the result of contact metamorphism of the saxonite on the gneiss, and the inclosing corundum was formed at the same time. This is similar to the large quantity of corundum occurring in biotite at the contact of saxonite and gneiss at the Bad Creek mine, Sapphire, N. C. (See page 62.)

CORUNDUM IN ENSTATITE.

Enstatite is rather common as a secondary product at many places where the corundum occurs in peridotite, and is thus an associate of corundum at these localities. Occurrences are rare, however, of corundum in an enstatite that is the original rock. Where thus found the rock is made up chiefly of the orthorhombic pyroxene, enstatite, in bladed interlocking crystals of a grayish color. It is always more or less decomposed into talc.

At the Rattlesnake mine, Sapphire, Jackson County, N. C., and on the West Fork of the French Broad River, in Transylvania County, N. C., corundum has been found sparingly in the borders of an enstatite rock.

Enstatite rocks are somewhat common in North Carolina, but accessory minerals in them are rare, and the most common one observed is chromite, in small grains.

CORUNDUM IN SERPENTINE.

At a number of peridotite localities in North Carolina and Georgia crystals and fragments of corundum have been found that were surrounded by serpentine, but nowhere in this southern section of the peridotite belt has corundum been found associated with the larger masses of serpentine. In Chester and Delaware counties, Pa.,[1] there is a long belt of serpentine rocks, part of which, at least, have been derived from peridotite rocks, and in connection with these, in the eastern part of Chester County and the western part of Delaware County, corundum has been found. In this, as in the peridotite, the corundum occurs near the contact of the country rock. Considerable plagioclase feldspar is associated with the corundum in the vein in a manner somewhat similar to the occurrence of this mineral at the Cullakeenee mine, Buck Creek, Clay County, N. C. In the South corundum has not been found as constantly associated with the serpentines as it is with the peridotites, but chromite is found very abundantly with many of them.

Cutting through the serpentines on the eastern slope of Spanish Peak, Plumas County, Cal., are white, coarse-grained dikes composed of corundum and oligoclase.

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[1] Geol. Survey Pennsylvania, C^4, 1883, p. 351.

CORUNDUM IN CHLORITE-SCHIST.

Besides being associated with chlorites in the peridotites just described, corundum is found in the long belts of chlorite-schist that traverse the country 10 or 12 miles southeast of Webster, Jackson County, N. C. These chlorite rocks, which sometimes attain a width of several hundred feet, are traceable for miles across the country. Almost the only constituent of these rocks is a green scaly chlorite, though sometimes there are present small grains of feldspar, and occasionally needles of amphibole. The chlorite is in small scales, never very coarse, as is sometimes the case in the zones about the peridotite, and often these are so minute as to give the rock a very compact appearance.

In one of these belts, on Caney Fork of Tuckasegee River, Jackson County, N. C., corundum is disseminated through the chlorite in small rounded masses, ranging in thickness from an inch to minute grains, and there the chlorite is not so compact as elsewhere. The corundum is usually wrapped with a white coating of mica, which is a secondary mineral derived from the corundum. The mica is often in radiating scales perpendicular to the outer surface of the corundum, and while in some cases it is very thin, in other cases it has replaced nearly all of the corundum, leaving but a grain of that mineral in the center.

CORUNDUM IN AMPHIBOLITE.

The occurrence of corundum in amphibolite is important, as the large deposits of emery corundum at Chester, Mass., are found in this rock. Under the head of amphibolite are included all those rocks that are composed entirely or chiefly of amphiboles. These rocks occur rather widely, including, as they do, those of Massachusetts, Georgia, and North Carolina, but with the exception of those that contain the emery they have not, up to the present time, been important in the production of corundum.

Associated with the peridotite rocks of Clay County, N. C., and the adjoining Towns County, Ga., are dikes of amphibolite, which are, for the most part, between the peridotite and the gneiss, although in some places they cut directly across the peridotite formation, but close to the contact of that rock with the gneiss. These dikes vary in width from 25 to over 300 feet, their average width being from 75 to 100 feet. The relation of these amphibolite dikes to the peridotite formation at Buck Creek, Clay County, N. C., is shown in fig. 5.

The groundmass of this amphibolite is a grass-green amphibole, containing 17 per cent of alumina, nearly 12 per cent of lime, and one-half of 1 per cent of magnesia, which is best classified under the edenite variety of aluminous amphiboles. The rich green color of the edenite is undoubtedly due to the presence of a small amount of chromic oxide, the analysis showing the presence of 0.38 per cent of this oxide. Many microscopic grains of picotite or chromite are scattered through the groundmass of the edenite. There is also present, in widely varying proportions, the plagioclase feldspar anorthite. The feldspar is not constant in all of the amphibolites, and where it does occur it varies in size from minute particles to masses as large as a pea.

The rock has often a very strikingly laminated structure, and grades from that to one which shows no lamination at all. It is exceedingly tough and very fine grained. The corundum, which occurs in the amphibolite as an accessory mineral, varies in size from minute particles to masses several inches in diameter, in which there are usually developed parting planes parallel to the unit rhombohedron. In color it varies from almost white to a deep ruby red, but the prevailing color is a deep pink.

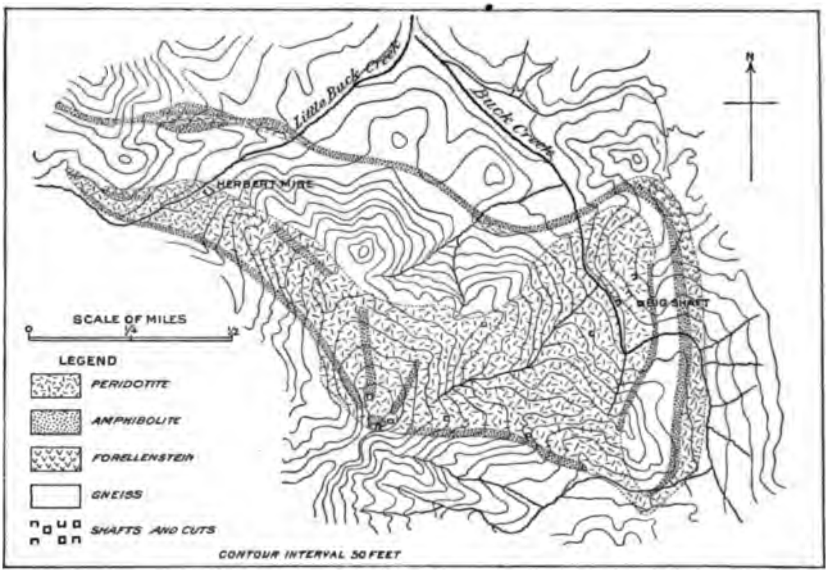

FIG. 5.—Map of the Buck Creek peridotite area, showing the relation of the amphibolite dikes.

On account of the exceeding toughness of the rock, and more particularly on account of the low percentage of corundum, these amphibolites are not of commercial value as a source of corundum; they do, however, make handsome mineral specimens.

On the eastern slope of the Blue Ridge, in the vicinity of Statesville, Iredell County, N. C., corundum has been found associated with an amphibolite composed of a dark-green hornblende. On account of the thickness of the soil and the depth to which these rocks have been decomposed, there are few places where the fresh rocks are exposed, and little is known of their extent. At Hunters, 7 miles west of Statesville, the amphibolite was exposed during

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[1] Bull. Geol. Survey North Carolina No. 11, 1896, p. 59.

exploration for corundum, which, according to Lewis,[1] was found to occur in fine brown vermiculite, developed in zones along the borders of and penetrating the amphibolite, and varying in thickness from a few inches to 3 or 4 feet. Fig. 6 is an ideal illustration of the occurrence of corundum in the amphibolite at Hunters. In this figure, *a* represents a feldspar vein that is sometimes encountered in the midst of the vermiculites, *b;* the feldspar is more or less altered to kaolin, and often bears corundum, although most of it was found in the vermiculite zones. *b* represents the vermiculite zones carrying the corundum, which is in crystals and in rounded masses of crystals clustered together. Margarite sometimes accompanies it, and large masses made up almost entirely of these two minerals have been found on the surface in this region. *c* represents radiating borders of actinolite that inclose large masses of what was once amphibolite, but which

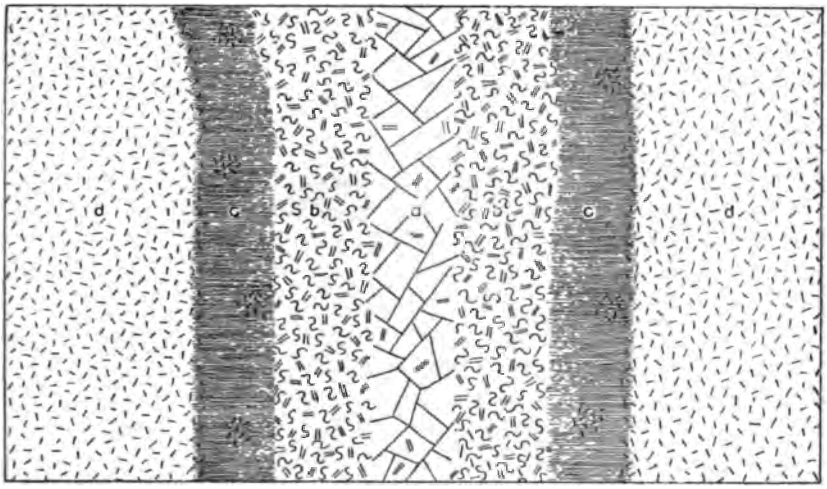

FIG. 6.—Ideal vertical cross section of corundum in amphibolite at Hunters, Iredell County, N. C.

is now nothing but a mass of ocherous clay, bearing occasional needles of hornblende and scales of vermiculite. The outer portions, *d*, are dark-green amphibolite.

CORUNDUM (EMERY) IN AMPHIBOLITE AT CHESTER, MASS.

The most widely known occurrence of corundum in amphibolite is that of the emery at Chester, Mass., an elaborate description of which is given by Prof. B. K. Emerson[1] in his exhaustive work on the geology of old Hampshire County, Mass.

Extending almost continuously across the State, north and south of Chester, there is a band of amphibolite that is conformable throughout its entire extent with the sericitic schists of this section of the

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[1] Mon. U. S. Geol. Survey Vol. XXIX, 1898.

State. The strike of this band of amphibolite is dependent upon the windings of the schists, and its dip is approximately 90°. Its width will average only a few rods, but in the vicinity of Chester, a few miles both north and south of the town, it is three-quarters of a mile wide, and it is in connection with this broad band that the emery is found. It occurs on the eastern side of the amphibolite and is separated from the sericitic schists by a narrow band of amphibolite, varying in width from an inch or two to nearly 18 feet. Sometimes there has been considerable serpentinization of the amphibolite, and the emery is separated from the schists by serpentine. Across the Westfield River from the point where the emery is first encountered, the amphibolite is replaced by serpentine, and it is in this bed of serpentine that crystals of this mineral, pseudomorphous after olivine, are said to occur, specimens of these being in the geological collection at Amherst College.

The amphibolite is in appearance a finely laminated rock made up of interrupted thin sheets of feldspar grains and of jet-black needles of hornblende, and usually contains more or less green epidote.

The sericitic schists on the west of the amphibolite, which are described by Professor Emerson under the head of the "Rowe schist,"[1] are biotitic and feldspathic, and often contain garnets that are more or less altered to chlorite. The schists on the east are described as the "Savoy schist,"[2] and are chloritic sericite-schists, mostly of a light-gray color, with a shade of green, due to the chlorite that is mixed with the muscovite. When the chlorite can not be seen with the eye it is readily detected under the microscope. In some places the proportion of the chlorite has increased until there are considerable aggregations of this mineral along the planes of lamination. Garnet and pyrite are also abundant in certain portions of the schist.

The emery vein can be followed for a distance of nearly 5 miles, starting from the point where it is first encountered, at the north end of the broad band of amphibolite, on the left bank of the Westfield River, just above the railroad bridge of the Boston and Albany Railroad. The general strike of the vein is a little east of south and runs for the most part parallel to the line of contact of the amphibolite and schist. Emery is not found throughout the vein, but can be almost continuously followed by means of streaks of chlorite. The vein varies in width from a few feet to 10 or 12 feet, the average width of the emery being about 6 feet. Upon both sides of the emery there are usually developed thin seams of chlorite varying from 1 inch to 6 inches or more in width. During the early history of the mine a seam of feldspar was encountered, about 12 inches wide, lying to the east of the emery and bordered on both sides by chlorite 3 or 4 inches wide. There is also more or less chlorite developed in the mass of the ore body, which varies from some portions that are an almost pure magnetite to others where there is an intimate admixture of magnetite and corundum. At the Sackett mine (described on page 68) the corundum, of a bronze color and luster, is coarsely crystallized, giving the ore a porphyritic appearance. Sometimes the corundum has crystallized out in blue and white crystals and in masses of a pound or two in weight.

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[1] Mon. U. S. Geol. Survey Vol. XXIX, 1898, p. 76.

[2] Ibid., p. 156.

ORIGIN OF THE EMERY.

It is a perplexing question to decide from the examination of this and the surrounding rocks whether the amphibolite is of sedimentary or igneous origin, for there are many indications that point to one and to the other. It is not improbable that some portions of this band of amphibolite, which extends across the State, may have been formed in one way and other portions in the other. Professor Emerson has examined this belt of rocks for practically its entire distance across the State, and while he is inclined to consider this band of amphibolite of sedimentary origin, he does not, if I understand him correctly, see anything antagonistic to the view that at least a portion of this amphibolite is an intrusive igneous rock. I have examined only that portion of the amphibolite adjacent to the emery vein, and from my observations I had come to the conclusion that this part of the amphibolite band was an igneous rock that had been intruded into the schists along their line of weakness, and that the magnetite and emery had been the first minerals to separate out from this magma. The reasons that have led me to this conclusion are given briefly below.

The position of the amphibolite, with a dip of practically 90°, lying between the Rowe and Savoy schists, which would have been a line of least resistance, suggests an igneous origin. What seems to me opposed to the acceptance of a sedimentary origin for this broad band of amphibolite is the separation of the vein of emery and magnetite from the sericitic schist on the east by a band of the amphibolite varying in width from a few feet to 18 feet, which, as far as can be judged superficially, is identical in every way with the amphibolite on the west of the vein. Yet, if the amphibolite and emery are of igneous origin, it would naturally be expected that emery would occur on the west side of the amphibolite, but none has been found there, although it is not certain that it does not occur.

Only a small amount of carbonates has been found in connection with the amphibolite and emery—no more than could readily be accounted for as secondary minerals.

Then, again, chromite has been found in connection with the serpentine that is associated with the amphibolite, some of which is undoubtedly an alteration of this rock. The presence of the chromite in the serpentine is to me a very good indication of its igneous origin, and its being the alteration product of a basic magnesian rock. This, then, would indicate the existence of former masses of a basic magnesian rock which have been changed into serpentine, the serpentinization continuing into the amphibolite for some distance.

The emery is not continuous along the strike of the vein, but occurs in a series of pockets in the vein that dip about 30° to the north. In going from one pocket to another along the strike there is often nothing to indicate the vein but a small seam of chlorite. The pockets are almost continuous in the direction of the so-called dip and hold this dip very constantly.

It seems to me that this portion of the amphibolite band was an igneous mass intruded after the formation of the sericitic schists, and either after or at the time these schists were tilted to their present position, and that the emery bed is the result of the differentiation of components of the mass that were held in solution by the igneous magma.

The theory that Professor Emerson[1] proposes is also probable, viz:

> That the emery-magnetite vein was originally a deposit of limonite which was formed by the replacement of limestone and into which alumina was carried by infiltrating solutions and deposited as allophane and gibbsite. The subsequent metamorphism of the bed, although it may well have been intimately connected with the extremely violent mechanical forces to which the strata have been subjected, was largely completed before these forces had ceased their activity, as is shown by the jointing and brecciation of the magnetite and emery. * * * The less altered ferruginous limestone below was changed into the epidotic amphibolite.

Many points that can be noticed support this conclusion, but these also indicate an igneous origin for the amphibolite. No fresh peridotite rocks have been observed in this section, and the nearest are probably across the Connecticut River at Pelham, where an igneous mass of saxonite is encountered. The presence, however, of chromite in the serpentine associated with this amphibolite is to me very good evidence for believing that the serpentines have an igneous origin, and it is very probable that they are alterations of former masses of an intruded peridotite.

If any deep mining is undertaken on the emery, new evidence may be brought to light that will determine decidedly what may have been the origin of these amphibolites and emery deposits.

CORUNDUM IN NORITE.

In the vicinity of Peekskill, Westchester County, N. Y., corundum has been found associated with norites, which have been described by G. H. Williams.[2] These rocks belong to the Cortland series, of which the prevailing rock type is one that is characterized by the presence of the mineral hypersthene. But though this mineral is there so abundant, a normal norite, containing nothing but a plagioclase feldspar and hypersthene, is extremely rare. There is more or less biotite, hornblende, or augite developed in nearly all rocks of this class, so that there is a gradual transition from normal norite to mica-diorite, hornblende-diorite, and gabbro. The intermediate varieties are much more common than the extremes, and they have been classified by Williams according to the prevailing nonfeldspathic mineral. Where hypersthene prevails the rocks are grouped as norites, being subdivided into normal norite, horneblende-norite, mica-norite, and augite-norite, according to the presence of these different minerals in the rock. These so grade into each other that no sharp line can be drawn between them.

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[1] Mon. U. S. Geol. Survey Vol. XXIX. p. 145.

[2] Am. Jour. Sci., 3d series, Vol. XXXIII, 1887, pp. 135, 191.

Associated with the norites, 3 and 4 miles southeast of Peekskill, N. Y., are deposits of magnetite and emery. It is not at all unlikely that these veins are the products of the differentiation of the molten norite magma, by which the basic portion of the magma has been concentrated near its outer surface, a gradual transition occurring toward the center to the more acid norite. This occurrence would be similar to that of the pyrrhotites which have separated out from the norites of Norway, as described by Vogt.[1] In that case the pyrrhotite was concentrated toward the border of the norite, and there is at some places a gradual transition from the pure pyrrhotite through a pyrrhotite-norite to the pure norite, while at others there is a sharp contact between them. The deposits of magnetite and emery are not in a continuous vein, but are more like segregated masses. Attempts have been made to work these for both iron and emery, but as iron-ore deposits they were soon abandoned. They are still being worked to a certain extent for emery by the Jackson Mills Company, of Easton, Pa.; the Tanite Company, of Stroudsburg, Pa.; and H. M. Quinn, of Philadelphia, Pa. An examination of the emery ore by J. D. Dana[2] and G. H. Williams,[3] has shown that the corundum component is often scattered rather sparingly through the ore, and what had formerly been supposed to be green chlorite was found to be the iron-magnesian spinel, pleonaste. The corundum in the emery varies from small, colorless grains to crystals 7 mm. in diameter, which show a hexagonal outline. In other parts of the emery the corundum grains are larger and of a bluish color.

The pleonaste, which is so commonly associated with the emery, has been found at the Cruger iron mine, in the eastern part of the township, as veins in a nearly normal norite, into which it passes by gradual transitions. The most compact specimens of the ore at this mine are found to contain the various mineral components of the norite, i. e., hypersthene feldspar, biotite, and garnet, no corundum having been observed here.

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[1] Zeitschr. für Prakt. Geol., Nos. 1.4. and 7, 1893.

[2] Am. Jour. Sci., 3d series, Vol. XX, 1880, p. 199.

[3] Idem, *Vol. XXXIII*, 1887, p. 194.

This gradual transition of the pleonaste and iron ore into the normal norite and the occurrence of the norite minerals in the compact ore are strong evidence that these ore bodies were formed by the differentiation of the molten norite magma.

In the vicinity of these norites there are small masses of peridotite, but no corundum has been found associated with them.

CORUNDUM IN BASIC MINETTE.

Near the entrance of Yogo Gulch, in Fergus County, Mont., two parallel dikes of igneous rock have been observed cutting through the limestones. These dikes are about 800 feet apart, and can be followed for over a mile in a nearly east-west course. Their general width is from 6 to 20 feet, but they are occasionally 75 feet wide. They are much decomposed near the surface, but in working them for the sapphires which they contain the nearly unaltered rock has been encountered.

The rock has a dark-gray, decided basic appearance, and is very tough, breaking with an uneven fracture. Scattered through it are light-green and white fragments, which are by far the most conspicuous of any of the mineral components of the rock. These are a pyroxene that is more or less decomposed and calcite. Some of these white fragments are probably the barium carbonate witherite, for in the concentrates obtained from washing the decomposed portions of the dike a considerable quantity of this mineral was found. Numberless crystals of pyrite, not over a millimeter in diameter and almost perfect trapezohedrons, were also found in these concentrates. A few scattered tablets of biotite, from 2 to 3 mm. in diameter, were observed. The sapphire variety of corundum is found rather sparingly in this rock in well-formed, flat, tabular crystals, some of which are half an inch in diameter.

Professor Pirsson, of the Sheffield Scientific School, has made a petrographical examination of this rock, and describes it as follows:[1]

> In the section the rock at once shows its character as a dark. basic lamprophyre, consisting mainly of biotite and pyroxene. There is a little iron ore present, but its amount is small and much less than is usually seen in rocks of this class. The biotite is strongly pleochroic, varying between an almost colorless and a strong, clear, brown tint. It occurs in ragged masses, rarely showing crystal outline, and it contains a large amount of small apatite crystals. The pyroxene is of a pale-green tint, with the habit of diopside, and is filled with many inclusions, now altered, but probably originally of glass; in some crystals these inclusions are so abundant as to render the mineral quite spongy. The grains sometimes show crystal form, but are mostly anhedral and vary in size, though the evidence is not sufficient to show two distinct generations.
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> These two minerals lie closely crowded together, and no feldspars are seen in the rock. The interstices between them consist of a small amount of a clouded, brownish, kaolin-like aggregate, which appears to represent some former feldspathoid

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[1] Am. Jour. Sci., 4th series. Vol. IV. 1897, p. 421.

component, possibly leucite, perhaps analcite. * * * Some calcite in agglomerated granules is also seen in the section.

This calcite does not appear to be of secondary origin, and is probably due to fragments of limestone that were picked up as the igneous mass forced its way up through the limestones and were converted into calcite.

As has been indicated by Professor Pirsson[1] in his paper, the amount of biotite in this rock shows that it is closely related to the minettes, and although it is lacking in feldspar it has the biotite and pyroxene of these rocks. It is a more basic type of these and is also similar to the shonkinites from the Highwood Mountains, Montana, described by Weed and Pirsson.[2]

The sapphires, which are all of some shade of blue, occur but rarely in the rock, and from their sharp, distinct crystals and their general distribution it is very evident that they have crystallized out of the molten magma at the time of its intrusion, similarly to crystals of feldspar in porphyry. The alumina of the sapphires was not an original constituent of the magma, but, as has been shown by Pirsson,[3] was due to inclusions of clay sediments taken up from the strata through which it passed. The Belt formation, consisting of clay shales of great but unknown thickness, undoubtedly underlies the limestones, and the included fragments of these shales were the source of the alumina of the sapphires. These included fragments would be dissolved by the molten magma and thus form local areas that would be very rich in alumina. As the magma began to cool corundum crystals would separate out in these alumina-rich areas.

CORUNDUM IN ANDESITE.

The occurrence of corundum in andesite in the United States was first described by Kunz.[4] He described a dike of andesite at Ruby Bar, near Eldorado Bar, on the Missouri River, 12 miles northeast of Helena, Mont. As described by him, this rock is in a dike cutting the slates of the country and is a vesicular mica-augite-andesite, which is made up of a groundmass of feldspar microlite and a brownish glass, in which are many particles of biotite and crystals of augite.

A similar occurrence has been observed by myself on the river 6 miles above Eldorado Bar, at French Bar, which is nearly 12 miles due east of Helena. At this locality a narrow dike, 3 to 6 feet wide, was found cutting through the slates of this section. The trend of the dike is N. 5° to 10° E., and it dips about 45° E. It was encountered by miners who were working the gravels of the bar for sapphires, and it has been exposed at but one point, so that its extent is not known.

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[1] Am. Jour. Sci., 4th series, Vol. IV, 1897, p. 422.

[2] Idem, Vol. I, 1895, p. 467.

[3] Idem, Vol. IV, 1897, p. 423.

[4] Idem, Vol. IV, 1897, p. 418; Min. Mag., Vol. IX, 1891, p. 396; Seventeenth, Eighteenth, Nineteenth, Twentieth Ann. Repts. U. S. Geol. Survey.

The rock is fine grained, of a rather light-gray color, and a decided basic appearance. Biotite is the most conspicuous mineral and occurs in small, flat, tabular plates, sometimes with distinct crystal outline, and up to a millimeter or two in diameter. In some specimens of the rock there are nodules, 5 to 10 mm. in diameter, that appear to be partially decomposed feldspar. The augite, which is prominent in the thin section, is not very apparent in the hand specimen.

Prof. L. V. Pirsson, of Yale University, has kindly examined thin sections of this rock for me and says that the rock is an altered augite-mica-syenite. It contains unaltered phenocrysts of a clear brown biotite which are well crystallized and which sometimes show slight resorption. It also contains phenocrysts of augite of a pale-brown color, variable in size, the largest 2 mm. across, replaced in the majority of cases by pseudomorphs of calcite. Besides this pseudomorphous calcite there is also a considerable amount of this mineral in irregular masses or streaks, which may in part be the filling of steam pores and in part be pseudomorphous after hornblende; this, however, could not be definitely determined. The minerals just mentioned are embedded in a groundmass of a brown glass which is everywhere speckled and dotted with microlites of a lath-shaped plagioclase feldspar. These are small and somewhat altered, so that their determination is not entirely satisfactory, but they appear to be oligoclase.

The rock is thus porphyritic, and the structure of the groundmass is typical for the hyalopilitic structure of Rosenbusch. In many respects it closely resembles the augite-porphyrite of Weiselberg, weiselbergite.[1]

One feature that is brought out in the thin sections is the somewhat laminated character of the rock in one direction, while in the slide cut at right angles to this a well-characterized flow structure is observed, all the longer axes of the minerals pointing in one direction. This indicates movements of flowing lava after the components had formed.

The corundum crystals occur very sparingly in the rock, and those that were observed were not so sharp and distinct as the blue sapphires.

I could obtain no definite information regarding the location of Ruby Bar and no one of the bars is now called by that name. It is possible that the bar described by Kunz is the same as the one now known as French Bar. From the description given of Ruby Bar, it is apparently not so far up the river as French Bar.

CORUNDUM IN SYENITE.

On a high foothill between Gallatin and Madison rivers, in Gallatin County, Mont., corundum has been found in a rock that is composed essentially of orthoclase feldspar, corundum, and biotite, with the feldspar predominating. This would classify the rock as a corundum-bearing biotite-syenite. The rock, for the most part, has a somewhat gneissoid structure, and in these portions the corundum is more or less finely divided, being in fine grains and small crystals. In other portions, where the corundum is coarsely crystallized, the rock has something of a pegmatitic character, and the corundum is surrounded by the orthoclase. The crystals of corundum vary in size; the largest ones are 1½ inches long and from a quarter to a half an inch in diameter. They are fairly well developed in the prismatic zone, but many of them, especially the larger ones, are rounded. In color they vary from bluish gray to almost colorless. The percentage of the corundum in the rock is large, and from a superficial examination it could be compared to the percentage of quartz in an average granite. The biotite is in small tablets, without definite crystal outline, and the tablets are often so arranged as to give the mass of the rock its gneissic appearance. The orthoclase did not show any crystal outline even in the larger fragments.

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[1] Rosenbusch, Mass. Gest., 3d ed., p. 953.

This occurrence of corundum was discovered by Prof. F. W. Traphagen, of Bozeman, Mont., to whom I am indebted for the specimens.

From the appearance of the hand specimens, this occurrence of corundum is similar to that in the syenite of Ontario, Canada, recently described by Blue[1] and Miller.[2]

CORUNDUM IN AMPHIBOLE-SCHIST.

At the Sheffield mine, in Cowee Township, Macon County, N. C., corundum has been mined in a saprolitic rock at various times for a number of years. In a shaft sunk to determine the depth of the corundum-bearing saprolite, solid, unaltered rock was encountered. The shaft, which was 87 feet deep, passed through the following rocks: The first 12 feet (*a*) was through the saprolite, in which there were seams of kaolin; the next 2 feet (*b*) were corundum bearing. From 14 to 28 feet (*c*) the same saprolite was encountered; the next 2 feet (*d*) were corundum bearing, followed by 10 feet (*e*, 30 to 40 feet) of the saprolite, and 2 more feet (*f*) that were corundum bearing. From 42 to 63 feet (*g*) the rock began to be less decomposed, and from 63 to 66 feet (*h*) another seam of corundum-bearing rock was encountered. From this point to the bottom of the shaft the rock became more and more solid, until at 77 feet (*i*) the fresh rock was encountered. These various seams in the rock are very pronounced. They dip 30° toward the west near the top, but become nearly horizontal near the bottom of the shaft. The seams of decomposed feldspar observed in *a* become less and less kaolinized, until in *i* the seams are of pure plagioclase feldspar. In *i* there are two seams of corundum similar to *b*, *d*, and *f*, although in the fresh rock the corundum seams are not as pronounced as in the saprolitic rock. There is often a considerable amount of feldspar bordering the seams of the corundum. The general trend of the rock is about N. 5° to 10° E.

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[1] Trans. Am. Inst. Min. Eng., Vol. XXVIII, 1898, p. 565, and Rept. Bureau of Mines, Ontario, Vol. VIII, Part II, 1899, p. 240.

[2] Rept. Bureau of Mines, Ontario, Vol. VII, Part III, 1898, p. 238, and Vol. VIII, Part II, 1899, p. 205.

From what could be seen of the solid and the saprolitic rocks, it is evident that the corundum occurs at intervals in the rock in seams a few feet in width. While the corundum may comprise 10 per cent or more of these veins, the amount in the rock that it would be necessary to mine would probably not be over a few per cent. The actual width of the dike is not known, but the saprolitic rock has been cut across for about 100 feet in a direction nearly at right angles to its strike.

The fresh rock at the bottom of the shaft is somewhat varied in appearance, and while it does not show any definite gneissoid structure, it sometimes closely resembles it. There are streaks in the rock a few inches thick, the more finely divided portions of which are distinctly gneissoid.

Some portions of the rock are decidedly porphyritic, and contain phenocrysts of a light-gray amphibole, a centimeter in diameter, in a groundmass of feldspar. A large part of the rock is made up, however, of small, roughly outlined prismatic crystals of an amphibole, probably hornblende, and irregular fragments of plagioclase feldspar. The hornblende is almost black in color, but in thin splinters it has a bronze luster and a deep resinous color. Biotite of a deep-brown color occurs sparingly, and a pink garnet is rather abundant. This part of the rock has a gneissoid structure and contains the corundum. The corundum is of a light to a purplish-pink color and occurs in nodules up to 2 or 3 cm. in diameter. Some streaks in the rock are highly garnetiferous, composed essentially of the garnet and plagioclase feldspar or of garnet and biotite. Chalcopyrite occurs very sparingly in these portions of the rock. Small particles of graphite have been observed in the coarsely crystallized portions.

Professor Pirsson has kindly made a microscopical examination of this rock, the results of which are embodied in the following paragraphs:

In thin section the microscope disclosed the minerals hornblende, plagioclase feldspar, garnet, biotite, muscovite, staurolite, and rutile. Hornblende is the most common, forming about two-fifths of the section, while of the remainder plagioclase and garnet occur in about equal quantities and the others in comparatively insignificant amounts.

The hornblende is formless, but tends to irregular columns, almost invariably extended in the plane of schistosity. It has very rarely a somewhat stringy tendency in its cleavage, but is usually homogeneous in broad plates. Its color is a clear olive brown, and it is somewhat pleochroic, but not strongly so. It is everywhere dotted by the small grains of garnet, which rarely show good crystal form. The garnet occurs associated also with the plagioclase.

The plagioclase occurs twinned according to the albite law only. In sections perpendicular to 010 the lamellæ show extinction as great as 30°, and the plagioclase is therefore rich in lime and as basic as labradorite, which it probably is. It shows strong evidence of shearing movement in the rock; it is often broken, exhibits rolling extinction, and the albite lamellæ are curved and bent. It runs along the planes of schistosity between the feldspars and forms a mosaic of angular broken grains.

Staurolite was found in rather broad, irregular grains, and rutile in small, irregular grains and well-crystallized prisms.

Professor Pirsson has indicated that the character and structure of this rock, composed chiefly of amphibole, labradorite, and garnet, suggest most strongly that it is a metamorphosed igneous rock of the gabbroid family. During metamorphism the augite of the gabbro would be converted into the brown hornblende; any iron ore that was present would be taken up by the hornblende and garnet. The rutile would have resulted from the titanic acid that is a regular component of the iron ores in these gabbro or diabase rocks. Staurolite is a mineral that would be rather naturally expected, as it is usually a mineral of metamorphism, and its natural home is in the schistose rocks. The feldspar has suffered the least (except the corundum) chemically, and shows only the shearing of dynamic processes.

The corundum does not occur in crystals, but in small fragments and in elongated nodules, which are cracked and seamed and appear to have been drawn out by the shearing processes. The general character and shape of the fragments of corundum would indicate that they were original constituents of the igneous rock and were not formed during its metamorphism.

The exact classification of this rock is not easy, but it is probably an amphibole-schist.

CORUNDUM IN GNEISS.

Corundum has been found in North Carolina in the ordinary gneiss of the same belt of crystalline rocks in which the peridotites occur. A number of occurrences, part of which may be corundum in gneiss, are described under the head of mica-schist; some of the rock that was at first thought to be a gneiss is now known to be a quartz-schist.

In the eastern part of Clay County, N. C., on the southern slope of Gross Ridge of the Chunky Gal Mountains, just above Thumping Creek, corundum has been found in the gneiss at a number of points. The rocks are so covered with soil and decomposed rock that the exact relation of the corundum-bearing gneiss to the normal gneiss can not be determined, but from what can be seen the former appears to be in narrow bands cutting through the latter. In structure the gneiss is distinctly laminated and very fine grained, except the portions immediately surrounding the corundum, where its constituents are much more coarsely crystallized, especially the biotite. It is a hornblende-gneiss, showing but little mica except where associated with the corundum.

The corundum occurs in nodules and crystals, half an inch and smaller in diameter, sometimes wrapped with muscovite in a manner similar to that described for the corundum in the chlorite-schists (p. 21). The crystals are prismatic, with the length of the prism usually two or three times its diameter. Occasionally they are very flat, with the prism not over a quarter of an inch in length and half an inch in diameter, and from their appearance these crystals are known locally as "button" corundum.

This occurrence of corundum in gneiss is in no way associated with the peridotite rocks of this section of the country. It is, however, very similar to the occurrence of corundum in quartz-schist described below. None of the peridotite rocks in which the corundum is so commonly found in this section of North Carolina have been found associated with these bands of gneiss.

CORUNDUM IN MICA-SCHIST.

It has recently been observed that portions or bands of the crystalline rocks of the southwestern part of North Carolina and the northeastern part of Georgia are corundum bearing. The composition of these rocks varies from those that are a normal gneiss to those that contain no feldspar and can best be described as quartz-schist composed of biotite, mica, and quartz. Some portions of the rock are rich in garnet, others are almost entirely free from this mineral, and occasionally there are also small bands of white quartzite. The rocks are distinctly laminated and are frequently intersected by granitic dikes, some of which are coarsely crystallized and of a pegmatitic character. These dikes are often parallel with the bedding of the schists, although many of them cut irregularly through them. Where these dikes are parallel to the bedding of the schists, the laminated structure of the latter is much more apparent. The general strike of these crystalline rocks is about northeast to southwest and the dip is about 30° NW.

Portions or bands of these schists are corundum bearing, but they are irregularly defined and gradually merge into the normal rock. They have a similar relation to the normal schists as the garnet-bearing bands of a gneiss to the normal gneiss in which they occur. These bands are not veins in any sense of the word, but are simply portions of the same mass of crystalline rocks in which corundum occurs as a constituent of the rock. They vary in width from a foot or two to 12 or 15 feet, but in these wider ones the corundum-bearing portion is not continuous and is intercepted by streaks of barren rock and granitic dikes. The bands can be traced for a distance of 5 or *6 miles* in a northeast-southwest direction, sometimes outcropping continuously for nearly a mile. There are at least two of these corundum-bearing bands which are parallel to each other and about 2 miles apart. The only variation that has been observed in them is in the percentage of corundum and garnet; otherwise they are identical. The amount of corundum is never large, and from determinations made on samples from various parts of the deposits it will not average over 4 or 5 per cent.

The corundum occurs for the most part in small particles and fragments that have no regular shape and are of a gray, white, and bluish-white color or almost colorless. It is also in crystals which vary in size from some that are very minute to some that are 2½ inches long and about one-half inch in diameter, and which are usually fairly well developed in the prism zone.

It is probable that these schists are the result of the metamorphism of sandstones and shales formed from alluvial deposits many thousand feet in thickness that were once the bed of the ocean. By lateral compression these have been folded and raised into the mountain ranges of this region. That these have been much higher than at the present time is very evident from the granitic dikes, which are of deep-seated origin. By decomposition and erosion the mountains have been worn down to their present condition, thus exposing the schists in contact with the granitic dikes which have aided in their thorough metamorphism. The shales were rich in alumina, and during their metamorphism the excess of the alumina crystallized as corundum along the planes of lamination, so that during the subsequent weathering the corundum has been left in knotty nodules, studding the surface of the rock and giving it the appearance of containing a high percentage of the mineral.

Genth[1] has described an occurrence of corundum in Patrick County, Va., about 2 miles from Stuart, where it has been found in the mica-schists on a knob of Bull Mountain. These schists are talcose and chloritic in character and are intersected by a number of granitic dikes. The portions of the schists in which the corundum occurs are gneissoid in character. This occurrence is decidedly different from that in Clay County, N. C., and more like the corundum-bearing schists near the headwaters of Caney Fork of Tuckasegee River, in Jackson County. The schists are in rather narrow bands that can be followed for some distance across the county. They are not true chlorite-schists like those described on page 21, but are made up largely of an elastic mica (probably muscovite) with some chlorite. The corundum occurs in rough crystals and nodules up to 1 inch in length and half an inch in diameter, of a grayish-white to white color and colorless. It is readily cleaned, and tests made upon the cleaned product show that it is well adapted for the manufacture of the vitrified wheel.

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[1] Am. Jour. Sci., *3d series*, Vol. XXXIX, 1890, p. 47.

CORUNDUM IN LIMESTONE.[1]

Extending from Byram, Sussex County, N. J., to Warwick Township, New York, a distance of about 25 miles, there is a belt of limestone having a general northeast-southwest strike, which widens out toward its northern end. About 1828 a specimen of sapphire corundum was found at Franklin Furnace in a detached piece of rock composed essentially of feldspar, and although search was made no more specimens were found in this vicinity. A few years later sapphire corundum was found in Newton Township, about 6 miles from Franklin Furnace, embedded in a feldspar and partly surrounded by a carbonate. This occurs near the contact of the limestone with the granitic rocks of this section, and it is very evidently the result of contact metamorphism. Dana reports the occurrence of sapphire corundum in these limestones near Newton and Vernon, Sussex County, N. J., and near Amity, Orange County, and Crugers Station, Westchester County, N. Y.

Prof. W. P. Blake[2] has described the occurrence of red sapphire corundum in the white crystalline limestones in Vernon Township, Sussex County, N. J. The finest specimens were ruby red in color and the others were of various shades of purple. The crystals were translucent, but no transparent ones were observed. They were embedded in the limestone and it is not improbable that crystals may occur in the similar rocks of the adjoining counties of New York.

The New Jersey occurrences seem to be well authenticated, but those from New York are not. In the report of the New York State Museum for 1895 on the mineral resources of the State there is no mention of the occurrence of corundum at this locality, and in the report for 1898 it is stated that no sapphire corundum is found in the State.

CORUNDUM IN CYANITE.

The occurrences of corundum associated with cyanite are quite widespread, and at times there are large masses of cyanite in which are numerous hexagonal crystals of corundum. At Litchfield, Conn.,[3] a mass of cyanite containing crystals of a dark, grayish-blue corundum, which was said to have weighed 1,500 pounds, was found. Large masses of cyanite have been found at various points in North Carolina in which there were well-developed crystals of corundum.

All the occurrences that have been noted have been from surface specimens, and the rocks in the vicinity have always been either schists or gneisses. It is without doubt in connection with these rocks that the cyanite and corundum originated. I do not believe that the cyanite is usually an alteration product of the corundum, as has been suggested by Genth,[1] but that they were both formed during the metamorphism of the rocks from which the schists and gneisses have been derived.

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[1] Am. Jour. Sci., 1st series, Vol. XXI, 1832, p. 319.

[2] Idem, 2d series, Vol. XIII, 1852, p. 116.

[3] Idem, 1st series, Vol. VI, 1823, p. 219.

SUMMARY OF CORUNDUM OCCURRENCES.

From the facts presented in the preceding pages, the occurrences of corundum are seen to be of much greater variety than was formerly supposed. While the large concentrated masses are still confined to the basic magnesian rocks, corundum is scattered in small amounts through a number of other rocks, and in the aggregate is in very large quantity.

Of the igneous magmas there are two that are very distinct from each other and that can be designated as the lime-magnesia and the alkaline series. In the first the mineral components of the rock are free from alumina, and where there has been alumina in solution in the molten magma it has all separated out either as corundum or spinel. In the second series, however, it is only the excess of alumina that has separated out as corundum, by far the larger percentage having united with the alkaline oxides to form a feldspar. In all the occurrences that have been examined this phenomenon has been constant.

It is very evident that there are magmas that contain an excess of alumina just as there are magmas with an excesss of silica, and it is evident that the alumina separates out as corundum in the same manner that silica separates as quartz in granitic rocks.

DISTRIBUTION OF CORUNDUM.

Most of the corundum that has been mined for abrasive purposes has been obtained from the eastern part of the United States, and has been found associated with the long belt of basic magnesian rocks extending from Massachusetts to Alabama. It is in the southern portion of this belt, in North Carolina and Georgia, that these rocks have their greatest extent, and it is in this region that the greatest quantity of corundum has been found. During the past few years, however, North Carolina is the only State that has produced any corundum and Massachusetts and New York the only ones that have produced any emery.

While the production of corundum has been limited almost entirely to one locality in North Carolina, it is not because this is the only known deposit of this mineral in quantity, but because the better deposits have not been worked. The emery deposit that has proved of the most economic importance, and which has produced practically all the emery mined in the United States, is at Chester, Mass. The amount of corundum that has been mined during the past year is very much less than the amount of emery, although its market value is twice that of the emery and there is a large demand for a well-cleaned commercial product. There are a number of reasons for this condition: the better deposits have been so controlled and tied up that they could not be worked, an imperfectly cleaned product has been put on the market, and other minerals have been substituted for this one.

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[1] Am. Philos. Soc., Vol. XIII, 1873, p. 22.

It is still too soon to predict to what extent recent discoveries of corundum in Canada and India will add to its production. Some of the Canadian deposits in Ontario were granted by the government to the Canada Corundum Company, Limited, of Toronto, and this company began extensive operations on the deposits at the beginning of 1900. This corundum, which occurs in a syenite similar to that described on page 30, has been thoroughly tested and has given fairly satisfactory results. The reports of the bureau of mines at Toronto show that this ore carries 14.7 per cent of corundum and that a very clean product is obtained. If the ore from this extensive Canadian bed continues to carry so large a percentage of the mineral, can be readily cleaned, and shows good abrasive qualities, this deposit should play an important part in the world's production of corundum (see page 88).

The India corundum occurs at Pipra, South Rewah. It is pink in color, with a fine-grained massive structure, and very tough. It is reported that there is an unlimited supply of this material, and it has already been used in this country in the manufacture of certain oilstones (see page 89).

In the following descriptions of localities those that contain sapphires are first taken up, then the corundum, and last the emery.

SAPPHIRE OR CORUNDUM GEMS.

The properties of a mineral that determine its rank as a gem are hardness, color, rarity, index of refraction, and luster. As an illustration of the extent to which the hardness affects the value of a mineral for gem purposes, sphalerite might be cited. This mineral, which has an index of refraction and a luster not far below that of the diamond, has a hardness of only 3.5 to 4, which effectually cuts it off from being a gem mineral.

Corundum has properties that place some of its varieties among the most valuable gems. With the exception of the diamond, it is the hardest mineral known, and the rarity and color of the ruby, the red corundum, has made that gem, when more than a carat in weight, more valuable than a diamond of corresponding weight. Corundum has been found in almost all the colors of the rainbow, and in the following list its gems have been classified according to color. They are very often designated by the prefix "oriental," to distinguish them from gems of the same name whose mineral composition and character are entirely different.

Sapphire or corundum gems.

Oriental or true ruby	Red of various shades.
Oriental sapphire	Blue of various shades.
Pink sapphire	Rose or pink.
White sapphire	Colorless.
Diamond spar	
Opaline	Pale blue or bluish white.
Girasol	
Hyaline	
Oriental amethyst	Purple.
Oriental emerald	Green.
Oriental topaz	Yellow.
Star sapphire	Opalescent.
Chatoyant	
Asteria	

The gems occur in the mines in three forms: First, as crystals, of which there are two distinct forms, (1) hexagonal prisms terminated by rhombohedrons and pyramids, sometimes with basal plane, the larger crystals being often rounded or barrel-shaped, and (2) flat, tabular crystals, where the basal plane is very largely developed; second, as transparent colored portions of larger massive pieces of corundum; third, as nodules of finer and clearer material in a mass of cleavable corundum, often having the appearance of rolled pebbles when separated from the mass of corundum.

ORIENTAL RUBY.

The most important of the sapphire gems is the oriental ruby, which varies from rose, pinkish, dark-red, and purplish to pigeon-blood color, the most highly prized. The rubies are very likely to be flawed, and when examined many of the cut stones are found to contain flaws of one character or another. The stones are often so cut that these flaws are distinguishable only by the aid of a magnifying glass.

The finest rubies of pigeon-blood color are those found in the Mogok district, about 90 miles north-northeast of Mandalay, in upper Burma. Small but fine rubies, often, however, of a pink color or a purplish tint, are found at Ratnapoora, in Ceylon, and of a dark-red color, similar to that of a garnet, in Siam. The rubies of the Burma district are found in situ in limestones, but the mining is confined almost entirely to the gravels.

At the Corundum Hill mine, Cullasagee, N. C. (see description, page 55), various shades of gem ruby corundum have been found. Two of the best rubies of good color that have ever been found at this mine are in the collection of Clarence S. Bement, of Philadelphia; there are also a number of fine ones in the United States National Museum at Washington. Many of the smaller crystals of various shades of pink to red are transparent near the outer surface and near their extremities, and from these small gems can be cut, but few that are worth $100 have been obtained from them. These smaller crystals are usually well developed and have a clean-cut form. The faces commonly developed on these are the base, c, 0001; the unit prism, m, $10\bar{1}0$; the unit rhombohedron, r, $10\bar{1}1$, and the pyramid, n, $22\bar{4}3$, more rarely observed.

The North Carolina locality for corundum gems which at the present time is attracting the most attention is the tract of land between the Caler Fork of Cowee Creek and Mason Branch, tributaries of the Little Tennessee River.[1] This tract is situated in Macon County, almost 6 miles below (north of) the town of Franklin. The nearest railroad station is Dillsboro, Jackson County, on the Southern Railway, about 12 miles to the east. The bottom of the valleys are about 2,500 feet above sea level, and the mountain peaks or knobs in the immediate vicinity rise to a height of 3,000 or 3,500 feet.

In the gravels of Caler Fork Valley pieces of crystals of red corundum were picked up by the people of the district, which led to the driving of two or three tunnels with the expectation of striking the vein and finding the corundum in sufficient quantity for commercial purposes. Work in this direction was soon abandoned, and for a number of years there were only prospecting and a little mining for the red corundum for gem purposes.

Systematic search was made, which revealed the fact that ruby corundum was to be found in the gravels of Caler Fork Valley for a distance of 3 miles. In 1895 the American Prospecting and Mining Company, of New York, bought out the old claims and began work on a systematic basis. The property owned by the company is a large tract on both sides of Caler Fork of Cowee Creek and nearly all the land in the northern part of the watershed of Mason Branch, a total area of about 5,000 acres.

The gravels in which most of the rubies have been found are covered by soil averaging about 2 feet in depth, but varying from 1 to 5, and they are about 3 feet higher than the present alluvial gravel of the stream. Pl. II, *A*, is a view of one of the gravel beds that is being worked for rubies, just west of the company's office. The gravel in this part of the valley, which is overlain with 3 to 5 feet of soil, is composed of waterworn masses of quartz and small pebbles of gneiss and quartz, and is much cleaner in appearance than the gravels a mile farther up the creek, at In Situ Hill, where most of the mining was carried on during 1898. Fifty feet above the level of this gravel another bed was discovered at In Situ Hill which carried ruby corundum.

In washing these gravels for the rubies, hydraulic processes have been used very similar to those used in the West in washing gold-bearing gravels. All the soil, as well as the gravel, is washed into a short line of sluice boxes (*a* of Pl. II, *B*) which lead into a large sieve

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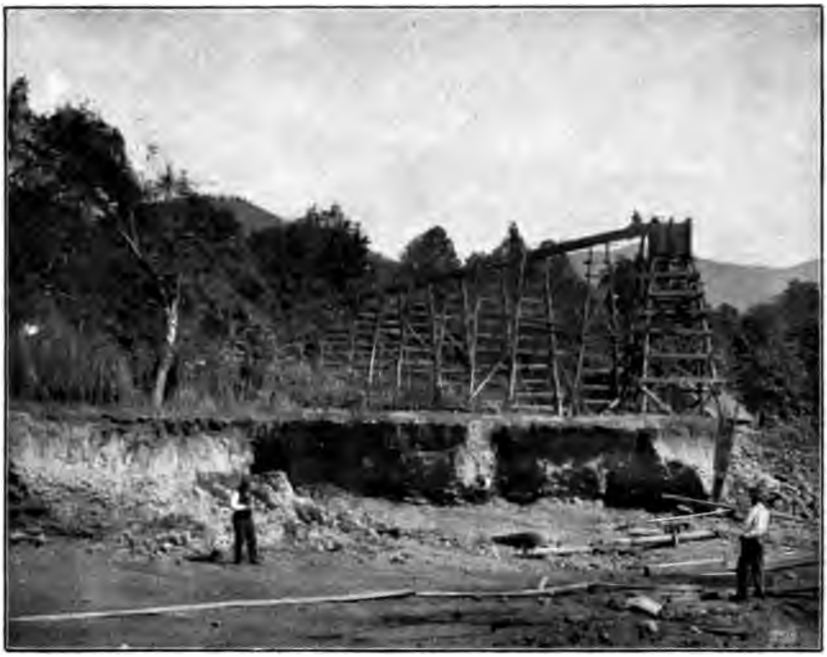
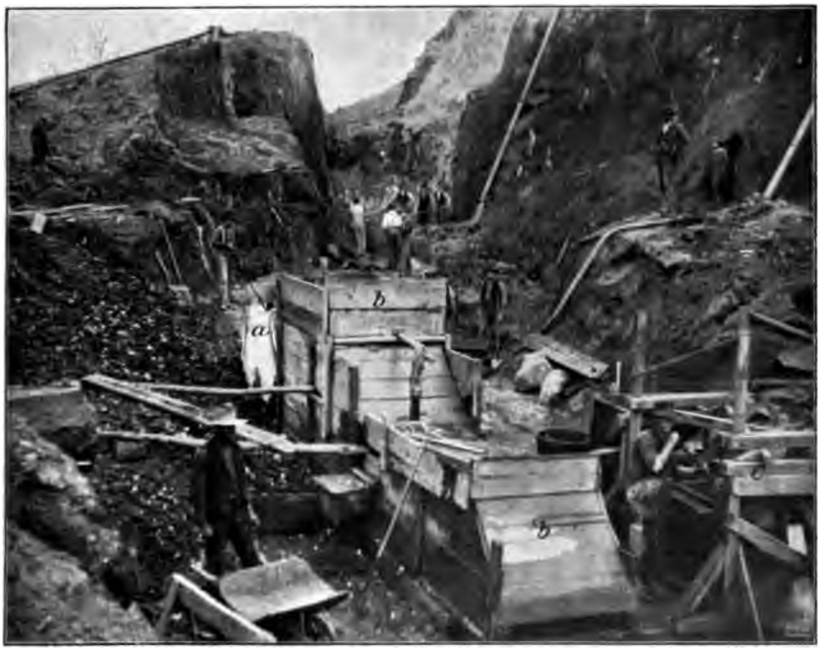
[1] Am. Jour. Sci., 4th series, Vol. VIII, 1899, p. 370.



A. BED OF RUBY-BEARING GRAVEL AT CALER FORK, COWEE VALLEY, MACON COUNTY, N. C.



RUBY MINE AT COWEE VALLEY, N. C.

Plant for washing the gravels is shown in the foreground; *a*, sluice box, *b*, sieve boxes; *c*, rocker.

box (*b* of Pl. II, *B*), where the large pieces of rock and bowlders are removed and most of the dirt and fine gravel is washed out. They are then shoveled into a rocker (*c* of Pl. II, *B*), where they are further cleaned and concentrated, the final concentration of the rubies being done by hand.

No basic magnesian rocks or serpentine derived from them, in which most of the corundum of North Carolina occurs, have been found in this valley. Corundum Hill and the Ellijay corundum region are, however, less than 10 miles to the south.

Although, in many respects, the occurrence of the rubies and their associate minerals in the Cowee Valley is similar to the occurrence of the ruby in Burma, no limestone has been found near the alluvial deposits, the nearest point at which limestone has been found being at Cullowee Gap, about 8 miles to the southeast.

The country rock of the district is a gneiss, of a gray, fine-grained variety, which has a great many small garnets disseminated through it. The rock for the most part is in a highly decomposed condition, but there are small exposures of the undecomposed rock in many places. The gravels in which the rubies are found rest on a soft rock known as saprolite, which is the result of weathering of the basic silicate rocks in place. By means of shafts and the workings at the gravel washings it has been shown that at a depth of 35 feet or more these saprolitic rocks contain fragments of the undecomposed rock and pass into such rocks as eclogite-amphibolite and a hornblendic gneiss.

A narrow dike of hornblendic eclogite a few feet in width is exposed near the present workings of the company and can be traced for about 100 yards.

No rubies have been found in the undecomposed rock, but at In Situ Hill small rubies of a rather pale color were found in a narrow band of saprolitic rock. This band was, however, cut off by slickenslides so that it could not be followed in any direction. There are four parallel slickenslides that have been exposed at one place in the workings, the general direction of the slides being N. 75° E. Some of these are 70 feet in length and of unknown depth. It is very evident that there has been a great deal of disturbance in this immediate vicinity through the breaking of the rock masses by faulting, the ready influx of water having caused the reduction of the rocks to their saprolitic condition.

In washing the gravels and masses of saprolite, masses of undecomposed rock have been uncovered, and in the center of these nodules of the pure hornblende rock have been found. The saprolite bordering these nodules often contains particles and crystals of corundum.

Less than 2 miles to the east of In Situ Hill, beyond Betts Gap of the Cowee Mountains, corundum of a gray to bluish color, but highly crystallized, has been found in hornblende-gneiss. One mile a little north of west, at the Sheffield mine, pink corundum has been found in amphibole-schist (see pages 31 and 58).

An association of corundum peculiar to this locality is with the garnet, rhodolite. Corundum and garnet occur not only constantly together in the saprolitic material and in the gravels, but corundum crystals have been found that bear the impression of the garnet. By means of wax a mold was taken of these impressions, and they were shown to be either the dodecahedron or trapezohedron. Then again some of the ruby crystals when broken are seen to have a garnet inclosed, and the garnet can often be seen in the transparent ruby crystal and the cut gem.

As has been said, there is no limestone in this immediate vicinity, and these rubies were probably derived from an amphibolite or eclogite. The usual flat tabular form of the crystals is one that seems to be characteristic of the gem corundum when found in igneous rock.

The Cowee Creek rubies frequently contain inclusions, some of which are very minute, known to jewelers as "silk," and these give rise to a cloudiness or sheen in the polished gem. Rutile and menaccanite often occur in the rubies and greatly mar their beauty and value. Some gems that were 3 or 4 carats in weight have been cut, which were free from inclusions, of fine color, and transparent. A great many smaller ones have been cut that are perfect gems. In color and brilliancy these gems are equal to the Burma ruby, and if the percentage of the unflawed transparent material increases but little this new field will be a worthy rival to the Burma field.

A considerable percentage of the transparent material is often very badly flawed by cracks due to parting, and by the inclusions of rutile or menaccanite, so that the percentage of perfect stone from this mine is small. This, however, is true of the rubies from the Burma field, for a large proportion of the rubies on the market to-day are usually more or less flawed with the parting cracks.

The pleochroism exhibited by the Cowee rubies is very marked, some of them being a very rich pigeon-blood red in the direction of the vertical axis—that is, looking down upon the basal plane—and changing to an almost pinkish-white color when viewed at right angles to this or looking through the prism. The pleochroism which nearly all the deep-colored varieties of corundum gems exhibit is one of the means of identifying a corundum gem; this often interferes with the cutting.

The ruby crystals[1] from the Cowee Valley show a very wide variation in their development. Although many of the crystals are so striated that no crystallographic measurements were possible on the reflecting goniometer, the faces were readily identified by means of the contact goniometer. On some of the crystals the faces were bright

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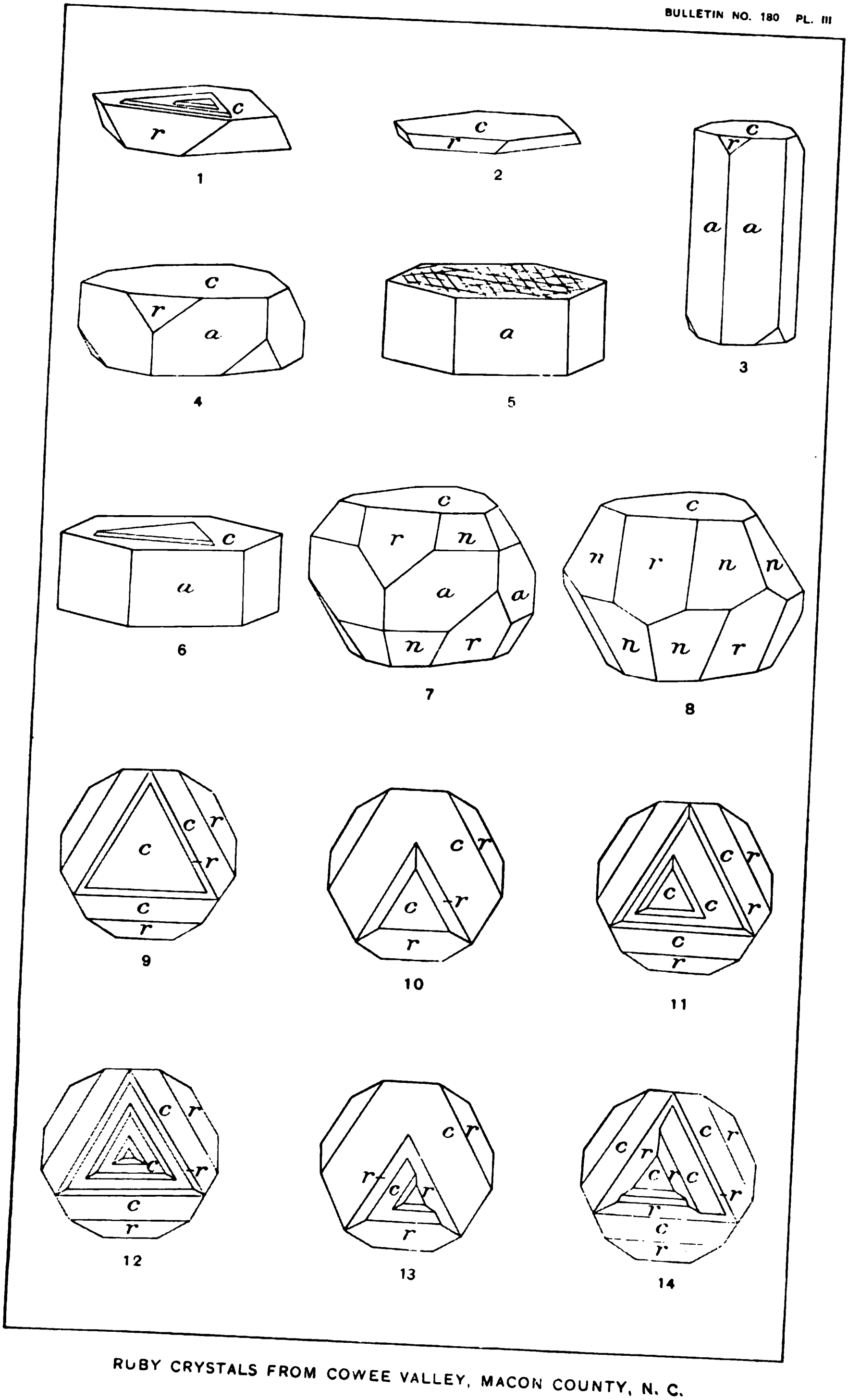
[1] Am. Jour. Sci., 4th series, Vol. VIII, 1899, p. 379.



RUBY CRYSTALS FROM COWEE VALLEY, MACON COUNTY, N. C.

and smooth, making them well adapted for measurement on the reflecting goniometer. These crystals are shown on Pl. III.

In the crystals examined two common habits were noticed; one is shown in figs. 1 and 2 of Pl. III, and is a combination of the base *c* (0001) and the unit rhombohedron *r* (10$\bar{1}$1); the other is represented by figs. 3–6 of Pl. III, where the prism *a* (11$\bar{2}$0) is very prominently developed. The rhombohedral crystals vary from those in which the base and the rhombohedron are disproportionately developed, the base having a diameter of 12 mm. and the rhombohedron of only 1.5 mm., to some (fig. 1 of Pl. III) in which the base and the rhombohedron are nearer one size. The majority of these crystals have, however, the base more largely developed, thus giving the crystals a flat, tabular appearance. This rhombohedral development is very similar to the sapphires from Yogo Gulch, Montana, described on page 52.[1]

On some of the prismatic crystals the prism reaches a length of nearly 15 mm. in the direction of the *c* axis, and has the rhombohedron *r* but slightly developed (fig. 3 of Pl. III), while on others the prism is very short and the rhombohedron is sometimes wanting, as represented in figs. 4 and 5 of Pl. III.

Another habit of these crystals is shown in figs. 7 and 8 of Pl. III, where the pyramid *n* (22$\bar{4}$3) is well developed. This face was identified by means of the contact goniometer, the measured angles approximating closely to those calculated. The usual form of these crystals is shown in fig. 7 of Pl. III, where the faces *c* (0001), *a* (11$\bar{2}$0), *r* (10$\bar{1}$1), and *n* (22$\bar{4}$3) are nearly equally developed. On some of the crystals the prism is very prominent, being 8 mm. in length in the direction of the *c* axis, while the pyramid is only 1.5 mm.; on others the pyramid is only very slightly developed. A few crystals were examined which showed only the presence of the base, the rhombohedron, and the pyramid, as represented in fig. 8 of Pl. III. The crystals, measuring up to 7 mm. in diameter, were doubly terminated and nearly perfect in their development.

The crystals represented by fig. 7 of Pl. III are similar to those described by Bauer[2] from the Burma district, and are almost identical in form with the sapphire crystals figured by me, from Emerald Bar, Canyon Ferry, Meagher County, Mont. (p. 50).

Although both the basal and rhombohedron planes are very often striated, it is only on the basal planes that the striations are sharp and distinct and can be measured. The striations are parallel to the three intersections of the base *c* and the rhombohedron *r* as shown in fig. 5 of Pl. III.

A very common development that was noticed on nearly all the flat rhombohedral crystals and on many of the prismatic crystals is a repeated growth on the basal plane of the rhombohedron *r* (10$\bar{1}$1) and the base *c* (0001), as represented in figs. 1–6 of Pl. III.

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[1] Also Am. Jour. Sci., 4th series, Vol. IV, 1897, p. 424.

[2] Neues Jahrbuch für Min., Geol., und Pal., Vol. XI, 1896, p. 209.

To illustrate better the variation in these growths, a series of drawings, figs. 9–14 of Pl. III, have been made in basal projection. In figs. 9 and 10 of Pl. III, which represent the more common development of these repeated growths, there is but one secondary rhombohedron and base, which sometimes has one of its rhombohedron faces a continuation of one of the rhombohedron faces of the crystal. Figs. 11 and 12 of Pl. III represent the repeated growths, the faces of which are separate and distinct from one another and from the faces of the main crystal. In the crystals represented by fig. 12 of Pl. III, the basal plane of the crystal has the appearance of being striated with triangular markings when the secondary growths are but slightly developed. In figs. 13 and 14 of Pl. III is represented a series of growths where a number of the rhombohedron faces coincide.

Some of the pyramidal crystals (figs. 7 and 8 of Pl. III) also show the development of the secondary growth of rhombohedron and base. The thickness of the rhombohedron of the secondary growth varies greatly: some are so thin that they appear like striations; some are 2 mm. in thickness. A few crystals were observed on which there was a secondary growth parallel to the prism 11$\bar{2}$0. This same style of development has been described by Bauer[1] as occurring in the Burma rubies.

The sapphire crystals from Montana, described on page 53, are strikingly similar in this respect to the Cowee rubies. Among the most noticeable associated minerals of these Cowee rubies is a delicate rose-colored garnet of great brilliancy, to which the name rhodolite[2] has been given. The rhodolite usually occurs in waterworn pebbles, but it has been found in very small dodecahedrons, and its close connection with the rubies in the small crystals of rhodolite inclosed by the garnet has already been mentioned.

The other accompanying minerals are: Quartz, rarely as pseudomorphous dodecahedrons; corundum crystals, of pale-blue, amethystine, and pink shades; spinel (pleonaste); gahnite, in octahedral crystals; chromite (rare); rutile; menaccanite; bronzite (transparent); tremolite; hornblende; iolite (colorless); cyanite; fibrolite; staurolite in perfectly transparent fragments of a garnet-red color; monazite in small crystals; zircon, small, brilliant crystals, and also the variety cyrtolite; pyrite; chalcopyrite; pyrrhotite; sphalerite; sperrylite in minute crystals; and gold.

Much of the work that has been done in Cowee Valley has been in the nature of prospecting to locate the extent of the ruby-bearing gravel and if possible to locate the origin of the rubies themselves. No work was done in the valley during the past year, but it is stated upon good authority that work will be begun again in the coming spring.

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[1] Loc. cit., p. 209.

[2] Am. Jour. Sci., 4th series, Vol. V, 1898, p. 294.

At the Mincey mine, Ellijay Creek, ruby corundum has been found from which several small stones could be cut. This occurs at the same locality as the bronze corundum, described below.

Another locality that is worthy of mention, and one that gives some promise of making a satisfactory showing in course of development, is the so-called gem mine on the property of Dr. C. Grimshawe, of Montvale, Jackson County, N. C. Rubies of good color, from which a number of fine but very small stones have been cut, have been found in the gravels of the stream. Blue and yellow corundum of gem quality is associated with the rubies. By following up the gravels the corundum was located in a small vein in the decomposed peridotite.

At the Cullakeenee mine, Buck Creek, and near Elf, on Shooting Creek, Clay County, N. C., masses of emerald to grass-green amphibolite are found, through which are disseminated particles of pink and ruby corundum, ranging in size from that of a pea to some as large as hickory nuts. The corundum is not of gem quality, but the combination of the green amphibolite and pink corundum makes very beautiful specimens, and if the rock is hard enough to admit of a good polish, this occurrence might furnish a decorative or ornamental stone of some value.

At the Mincey mine, on Ellijay Creek, Macon County, and about 2½ miles northeast of Corundum Hill, there occurs a peculiar brown or bronze corundum, known locally as "pearl corundum," which shows distinct asterism, both by natural and artificial light, when the stone is cut en cabochon. In natural light these corundums all show a bronze luster and are somewhat similar to the cat's-eye, but in artificial light the star is more distinct. Most of the bronze corundum is in rough crystals, but some have been found that have the prismatic faces smooth and well developed, and these are often dark, almost black, in color.

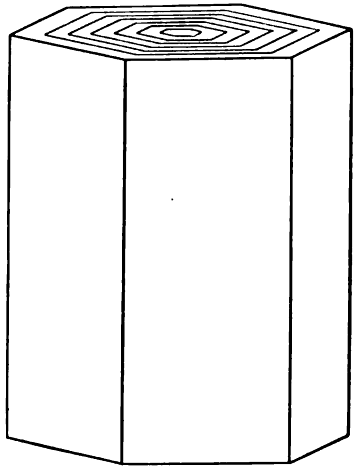

FIG. 7.—Corundum crystal, showing concentric hexagons on basal plane.

Asterism has been noticed in many of the rubies and sapphires from Cowee Valley and in a few of the sapphires from the Montana deposits. This asterism, according to Von Lasaulx, is sometimes produced by rifts due to the basal parting. These rifts, when examined with the microscope, are seen to be very thin, sharp, and rectilinear, and are parallel to the edge of the prism onto base.

In other cases asterism is undoubtedly due to the rutile or other mineral that is inclosed in the sapphires, which intersect each other at angles of 60°, and form a "sagenite web" or similar structure.

On many of the corundum crystals, especially of the sapphire variety, concentric hexagons were observed on the basal plane, as represented in fig. 7. The edges of the hexagon are parallel to the edges of the prism faces onto base, and the plane of the hexagon is parallel to the base. In a few of the transparent crystals this hexagon was observed as a web in the midst of the crystal, the plane of the web being parallel to the basal plane.

ORIENTAL SAPPHIRES.

The finest sapphires that are known are found in Burma and Ceylon, and have the rich, deep-blue color for which the oriental stone is noted. Sapphires of a rich, velvety blue and some very good stones of a lighter color have been obtained from Simla Pass, in the Himalaya Mountains. Siam has also produced some sapphires of very good color. The sapphire corundum from Australia is generally of an opaque, milky-white color.

NORTH CAROLINA SAPPHIRES.

No corundum gems were found in the United States until the opening of the Corundum Hill corundum mine at Cullasagee, Macon County, N. C., in 1871. This corundum is mined for abrasive purposes, but in certain parts of the deposit crystal corundum is occasionally found that is of a decided gem character, and, again, many of the fragments of the corundum have certain portions that are transparent. A number of very handsome dark-blue sapphires from this mine are in the United States National Museum, one of which weighs a carat.[1]

Yellowish and blue colors in the same specimen are rather common, and are sometimes sharply separated into consecutive bands, while in other specimens the colors merge into one another.

Sapphire gems of all the different colors have been found at Corundum Hill, and I have in my collection cut gems representing all these various colors. Many of them are, however, very small.

During the past ten years but few gems have been obtained from this mine, for the reason that the portion of the deposit from which these crystals were formerly obtained has not been worked. In the alluvial deposits below this portion of the mine many handsome crystals can be obtained by washing the gravel.

The green sapphire, which is the oriental emerald, is one of the rarest of gems. The Corundum Hill mine is the only place in this country at which the emerald-green sapphire has been found, and it

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[1] Kunz: Gems and Precious Stones of North America, 1890, p. 40.

occurs very sparingly here, although the yellowish and light-green colors are not uncommon. What is probably the finest known specimen of the oriental emerald in the world came from this mine, and is now in the Bement collection. It is a crystal 4 by 2 by 1¼ inches; part of it is transparent, and several very fine gems could be cut from it.

At the Sapphire and Whitewater corundum mines, near Sapphire, Jackson County, N. C., fragments of sapphire of a fine blue color have been found, from which small but good gems have been cut.

Associated with the green amphibolite rock near Elf post-office, Clay County, N. C., deep-blue sapphires have been sparingly found. These bear the same relation to the amphibolite as the red and pink sapphire described on page 45.

MONTANA SAPPHIRES.

The only systematic mining that has been undertaken for sapphires is in Montana. Sapphires were first found in this State by miners who were washing the gravels of the bars on the Missouri River, to the east of Helena, for gold. These were first described in 1873 by J. Lawrence Smith,[1] but it was not until 1891 that actual mining was begun. During that year a number of companies were organized to work these bars for sapphires.

These bars are located from 12 to 18 miles east and northeast of Helena, and have been followed for a distance of about 12 miles from Canyon Ferry down the river to American Bar. At various intervals these bars have been worked for the sapphires and are designated by the following names, starting with the one that is farthest up the river: Emerald Bar, Cheyenne Bar, French Bar, Spokane Bar, Metropolitan Bar, Ruby Bar, Eldorado Bar, Dana Bar, and American Bar. The location of these bars is shown on the map (Pl. IV).

A few sapphires have been found as far down the river as Beartooth, but sapphires have not been found in large quantity below American Bar.

Above Emerald Bar there have been no sapphires found on any of the bars, but in the gravel of Magpie Gulch, less than a mile above Emerald Bar (at Canyon Ferry), many sapphires have been found by miners who were washing the gravel for gold. No sapphires have been found in situ in this gulch, but Kunz[2] has noted the occurrence of sapphires that were found in a dike of vesicular mica-augite-andesite which was about 6 feet wide and cut through the green slate below the gravels. In the gravel deposits at French Bar, about 3 miles below Canyon Ferry, a narrow dike was encountered last summer, 3 to 6 feet in width, that had greenish sapphires scattered sparingly through it.

This dike was encountered about 50 feet above the river and its strike as it cuts through the slate is N. 10° E., the dip being about 45° W.

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[1] Am. Jour. Sci., 3d series, Vol. VI, 1873, p. 185.

[2] Min. Mag., Vol. IX., 1891, No. 44, p. 396.

This rock is undoubtedly of the same character as that described by Kunz as occurring at Ruby Bar. From the occurrence of these two corundum-bearing dikes of andesite it would seem that the source of the sapphires found in the various bars along the Missouri River is a series of small parallel dikes with a slight northeast-southwest trend, like those described. As the sapphires are scattered so sparingly through these dikes, the amount of decomposition and erosion that was required to liberate those that are now found in the gravels must have been simply enormous.

The beds of gravel in which the sapphires occur are from 10 to 50 feet thick and rest for the most part upon slate, in bluffs that rise nearly 50 feet above the river. At Emerald Bar the gravel beds are nearly 130 feet above the river and rest upon granite rock.

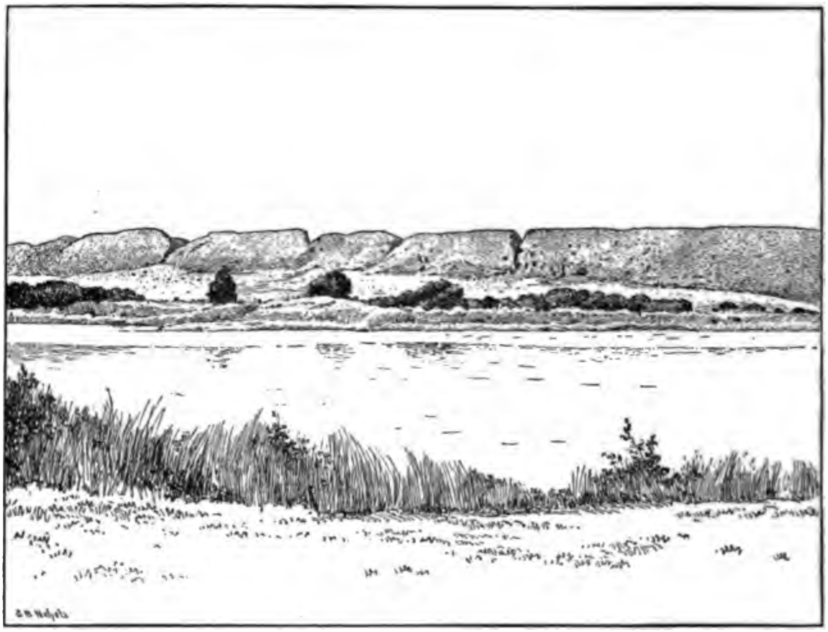

FIG. 8.—Spokane Bar sapphire deposits, Lewis and Clarke County, Mont.

Most of the mining has been done at Spokane and Eldorado bars. The former locality is near the center of the sapphire deposits and on the west side of the river about 16 miles due east of Helena. In 1895 these beds of gravel, which are 8 to 18 feet thick, were extensively mined by an English company known as the Montana Sapphire and Ruby Company. The gravels were washed by hydraulic methods and a great many gems were obtained, most of which were sent to England. This company also controlled or owned French Bar and Dana Bar on the west side of the river and Eldorado Bar on the east side.

It was reorganized in 1897 as an American company, known as the Eldorado Gold and Gem Company, with A. N. Spratt, of Oakland, Cal., president, and Frank Spratt, of Helena, Mont., manager. No work has been done at any of the bars by the present company. This bar is shown in fig. 8, the bluff rising from the river being 30 to 50 feet high.

Directly across the river from Spokane Bar, but about three-fourths of a mile from the river, is Metropolitan Bar, which has been worked during the summer of 1899 by different men who have staked out individual claims. The gravels are from 6 to 20 feet thick, and are washed in hand rockers, the water being obtained from shallow wells. Several of the claims are owned by Robbin Bird, Charles Johnson, and John Durrant, of Helena, Mont.

Above Spokane Bar, French Bar, Cheyenne Bar, and Emerald Bar no regular mining has been done during the last few years, but frequently different persons have worked in the old drifts for a few days at a time, washing by hand the gravel obtained.

A large part of the work done at Emerald Bar has been under ground, by means of shaft and drifts. Henry Crittenden, of Canyon Ferry, has done a large part of the work here, and still controls the deposits.

Below Spokane Bar, at Dana Bar, Eldorado Bar, and American Bar there was no mining for sapphires during 1899.

Most of the gems that have been obtained from these bars during 1899 have been put on the market through the Helena Lapidary Company, of Helena, Mont., of which William Knuth is manager. Mr. Knuth has done considerable work on these bars, and has been instrumental in the development of the Montana gem fields.

As mining investments these sapphire deposits have not thus far been financially successful, partly on account of the heavy capitalization of the companies who have bought the mines and partly on account of the color of the stones. They are, for the most part, of a pale-greenish or greenish-yellow color, and do not command a very high price in the market. Occasionally pink and yellow ones have been found that have cut good gems. Stones approaching a red or blue color are, however, extremely rare.

There are still a great many sapphires in the gravels that have not been worked, but on account of their color it is rather doubtful whether under the most favorable conditions it will pay to mine them.

The crystals from all these bars show the same development, and are prismatic in habit. The prism, *a* $(11\bar{2}0)$, is always present, and is usually in combination with the base, *c* (0001), and the unit rhombohedron, *r* $(10\bar{1}1)$, as represented in fig. 9, *A*. Some of the crystals have the prism very short and the rhombohedron is wanting, giving the crystal a very tabular appearance (fig. 9, *B*). A pyramid of the second order, *n* $(22\bar{4}3)$, was observed on some of the crystals in addition to the base and unit rhombohedron, and is represented in fig. 9, *C*.

The crystals are usually rough and more or less striated, so that no measurement could be made upon the reflecting goniometer, but sufficiently accurate measurements could be obtained with the contact goniometer to identify the faces.

The largest crystal that has been observed from any of these bars was one from Eldorado Bar that was nearly an inch long and three-eighths of an inch in diameter.

A repeated growth was observed on some of these crystals, but not in the variety of forms seen in the Cowee rubies (p. 43) and the Yogo Gulch sapphires (p. 52). Only one form of growth was observed, represented in fig. 9, *A*, which is a combination of the unit rhombohedron and the base.

Since the discovery and mining of sapphires from the Missouri River bars sapphires have been found at three other localities in Montana—at Rock Creek, Granite County; at Cottonwood Creek, Deerlodge County; and at Yogo Gulch, Fergus County.

The first two localities are about 80 and 30 miles southwest of those on the Missouri River, and the last one is about 80 miles to the northeast. From these sapphire deposits stones of deeper colors have been obtained, those from the first two being of all colors from blue to red, while those from the last are all blue.

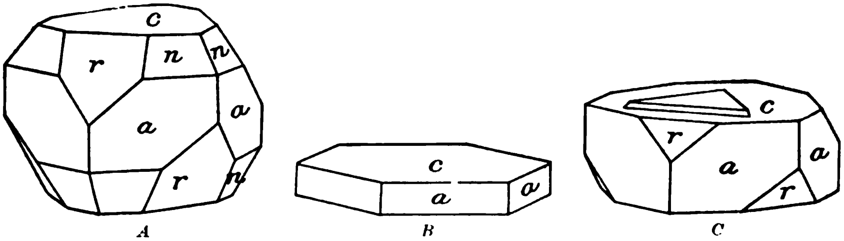

FIG. 9.—Sapphire crystals from Missouri River bars, Montana.

ROCK CREEK SAPPHIRES.

For information concerning the sapphire deposits of Rock Creek, I am indebted to Mr. William Knuth, of Helena. All the sapphires that have thus far been found in this section are in the gravel deposits on the West Fork of Rock or Stony Creek, in the southern part of Granite County, about 35 miles southwest of Phillipsburg, the county seat, and 30 miles nearly west of Anaconda, Deerlodge County. (Pl. IV.)

The sapphires are found in rather a limited area, which is bounded roughly by the gravels of Cold Creek, Myers Creek, tributaries of the West Fork of Rock Creek, and that portion of Rock Creek lying between them.

These gravels were extensively worked during the summer of 1899, principally by William Knuth, of Helena, and William Moffitt, of Phillipsburg. Altogether about 200,000 carats of rough sapphires were obtained. Of these about 12,000 carats are fit for cutting. In color they are much more varied than those from the Missouri River bars, and the prevailing color, which is greenish to bluish green, is deeper. No deep-blue sapphires like the oriental stones have been found, but paler blue ones have been obtained, from which very handsome sapphires 2 or 3 carats in weight have been cut. Some of the finest yellow sapphires (oriental topaz) that I have ever seen have been found at Rock Creek. One of these weighed close to 2 carats when cut. Pale green and bluish green are among the common stones, some cutting gems of 5 to 8 carats in weight. A number of beautiful pink sapphires have also been found.

Few red and ruby-colored crystals have been found and none that would cut a gem over a twelfth of a carat in weight. These colors are extremely rare in the Montana sapphire deposits.

The crystals and fragments of sapphires that are found in these gravels do not show as much abrasion as those from the Missouri River, probably because they have been carried a shorter distance from where they originated.

In habit the crystals are very similar to those already described from the Missouri River, and fig. 9 will also illustrate very well the character of the Rock Creek crystals. One type that is very noticeable is a short prismatic crystal, whose diameter nearly equals its length. A parallel growth on the basal plane is only occasionally observed, and is composed of the basal plane and unit rhombohedron.

No sapphires have as yet been found in situ, but a few have been found in the gravels that were embedded in the original matrix. Mr. Knuth, to whom I showed a specimen of the andesite containing sapphires from French Bar, said that it very closely resembled the small fragments of rock carrying sapphires that he had found at Rock Creek. It is not at all improbable that these sapphires originated in the same type of rock as those of the Missouri River and that small dikes of andesite will be found in the divide between Myers, Cold, and Quartz creeks. A very few sapphires have been found on Quartz Creek.

While the sapphire gems from Rock Creek do not command so high a price as the ruby and the deep-blue sapphires, and are regarded more as fancy stones, they are coming to be quite highly prized by many who are acquainted with them. As yet but few of the Rock Creek sapphires have been put on the market except locally at Helena, and it seems to me that it can be confidently predicted that these sapphires will become important in the jewelry trade when they are once known.

COTTONWOOD CREEK SAPPHIRES.

The sapphire deposits on Cottonwood Creek are in Deerlodge County, about 30 miles southwest of Helena and 10 miles east of Deerlodge, the county seat. There has not been a great deal of work done on this creek, so that the extent of the sapphire-bearing gravels is not known. The sapphires are similar in character to those of Rock Creek, but they are apt to be of lighter color and not of such a variety of colors. What little work was done on the creek during the past summer was by Franz Cobalt, of Helena, and according to him there were but few sapphires taken out of the gravels. Future development at this locality may show these deposits to be of considerable importance and extent.

YOGO GULCH SAPPHIRES.

The sapphires that are the most widely known and that have attracted the most attention have been obtained in Fergus County near the entrance of Yogo Gulch, on the Yogo Fork of Judith River. This locality is on the eastern slope of Prospect Ridge of the Little Belt Mountains, about 75 miles northeast of Helena and 15 miles a little south of west of Utica, which is the nearest town, and which is on the Judith stage line. The sapphires were first found in the gravels of Yogo Fork, and in following these up the creek their original source was located in dikes that extend across the county for a mile and a half.[1]

There are two parallel dikes about 800 feet apart, with a general east-west trend, which vary in width from 15 to 75 feet. The mineralogical composition of the rock shows that it has a close affinity with minette and shonkinite, as described on page 28.

The alluvial deposits below these dikes have been pretty thoroughly worked for the sapphires, and mining operations are now confined almost entirely to the dikes themselves. These dikes, the upper portion of which is thoroughly decomposed, have been worked by means of open cuts, the limestone making fairly firm walls. By hydraulic processes the decomposed rock was readily broken up and washed into sluice boxes. As the mining extended deeper the rock was much less altered and it was necessary to leave a great deal of it exposed to the atmosphere from one season to the next, before it could be broken up and run through the sluice boxes. At a number of points the almost perfectly fresh rock has been encountered, and from this it will be a difficult problem to separate the sapphires. The percentage of sapphires in the rock is small and if it were the unaltered rock that had to be worked for them the deposit would not be of economic importance.

The sapphires occur embedded in this rock in distinct crystals from less than a millimeter in diameter to some that were over 15 mm. Their color, as far as I have observed them, is always a blue, varying from light blue to a very few that showed the dark blue of the Ceylon stone. The prevailing color is a bright blue.[2]

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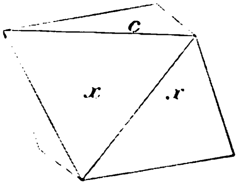
[1] The geology of the district and a full description of the mines and workings, by W. H. Weed, will be found in the Twentieth Ann. Rept. U. S. Geol. Survey, Part III, 1899, pp. 454-460.

[2] Kunz: Am. Jour. Sci., 4th series, Vol. IV, 1897, p. 420.



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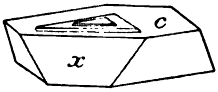

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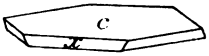

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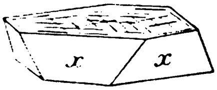

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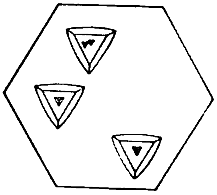

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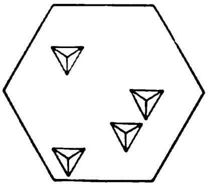

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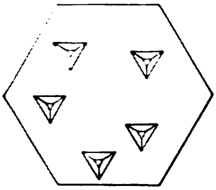

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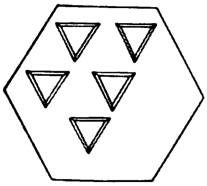

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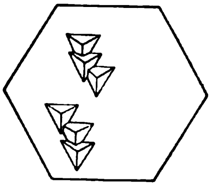

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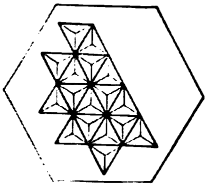

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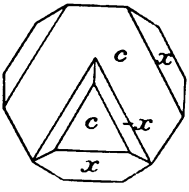

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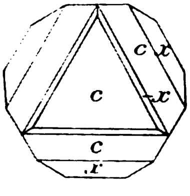

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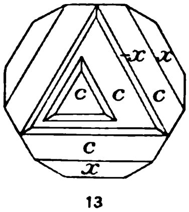

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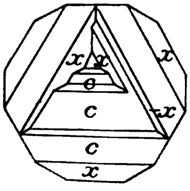

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SAPPHIRE CRYSTALS FROM YOGO GULCH, FERGUS COUNTY, MONT.

While the color of these sapphires is not as dark as the highly-prized Ceylon stones, they show a richness and brilliancy not equalled by the oriental stone. They not only show a strong rich color by transmitted light, but their color is almost as good by reflected light. Then again, while many blue sapphires make beautiful day stones but are dull at night, the Yogo sapphire is a very brilliant night as well as day stone.

The crystallography of these sapphires is markedly different from that of the sapphires of the Missouri bars and Rock Creek (page 50). The latter all show a prismatic development, while the former are all rhombohedral crystals, none of which show the presence of any prism face.[1]

The crystals are etched and striated to such a degree that no crystallographic measurements on the reflecting goniometer were possible; but sufficiently accurate angles were obtained with the contact goniometer to permit the identification of the faces. The only two faces that could be identified were the base c (0001) and the rhombohedron x $(30\bar{3}2)$ which is a new face for corundum. On one crystal two very small faces were observed which were too small to be measured with the contact goniometer, but were probably the faces of a pyramid of the second order.

In determining the rhombohedron, ten or more independent measurements were made of $c \wedge x$. These varied from 66° to 68°, but approximated closely to 67°, which agrees very well with the calculated value, 67° 3′, for $0001 \wedge 30\bar{3}2$. These crystals are represented on Pl. V.

The crystals are developed, as shown in figs. 1, 2, and 3 of Pl. V, the prevailing type being like fig. 3 of Pl. V. The crystals vary from those where the base is very largely developed, having a diameter of 8 mm., while the rhombohedron is only 1 mm., to those that have the base and the rhombohedron equally developed (fig. 1 of Pl. V). Where the faces are more equally developed, the rhombohedral faces are generally rounded.

The basal plane often shows characteristic striations which are parallel to the three intersections of the base c and the rhombohedron x, as shown in fig. 4 of Pl. V. These lines are sharp and distinct and on the very flat crystals can easily be measured when examined under the microscope. The rhombohedral faces are very roughly striated without showing any distinct parallel lines.

One very common development of these crystals is a repeated growth on the basal plane of the rhombohedron x $(30\bar{3}2)$ and the base c (0001), as represented in fig. 2 of Pl. V. These growths are exceedingly varied, as is shown in figs. 11–14 of Pl. V, where they are drawn in basal projection. In fig. 11 of Pl. V there is but one secondary rhombohedron and base, which has one of its rhombohedron faces a continuation of one of the rhombohedron faces of the crystal.

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[1] Am. Jour. Sci., 4th series, Vol. IV, 1897, p. 424.

Fig. 12 of Pl. V represents a repeated growth, each face of which is entirely distinct from the faces of the main crystal. In fig. 13 of Pl. V there are represented two, and in fig. 14 of Pl. V a series of such growths, where a number of the rhombohedral faces coincide. These growths occur most frequently on the flat crystals. The thickness of the rhombohedron rarely reaches 1 mm. and often they are so thin that they appear like striations.

This repeated growth is very similar to that described as occurring on the Cowee rubies (p. 43). Bauer,[1] in an article entitled "Ueber das Vorkommen der Rubine in Birma," has described this same style of development as occurring on the Burma rubies, but it is not so general as on the Montana corundums.

Etching figures.[2]—The etching figures which were observed on nearly all the crystals examined were on the basal plane. The figures are very perfect, and although showing many different forms, they all have a rhombohedral symmetry. Fig. 5 of Pl. V represents the common etching figure, which is a rhombohedral depression terminating in a point. The edges of the depression are sharp and well defined, as are also the intersections of the rhombohedral faces of the depression. These rhombohedral faces were smooth and gave fair reflections of the signal on the reflecting goniometer. In measuring them the entire crystal except the depression to be measured was covered with a thin coating of wax. Two different crystals were measured, which gave for rhombohedron on rhombohedron 22° 30′; this corresponds to the rhombohedron $10\bar{1}7$, for which the calculated value is 21° 50′. Figures of the same style were observed whose edges were parallel to those of the negative rhombohedron; these, however, are not common in isolated forms.

Another common form is represented in figs. 7 and 9 of Pl. V, where the depression is bounded by the basal plane, which at times is so large that the rhombohedral plane is hardly visible. Fig. 6 of Pl. V represents etching figures, where, on the basal plane of a shallow depression, there is one additional etching figure and sometimes two. These second etching figures are like the common ones shown in fig. 5 of Pl. V. The outer rhombohedral contour of these figures is generally rounded. This is also usually the case with the deeper depressions.

Often the etching figures are intergrown, fig. 8 of Pl. V, and when many of these occur together they have the appearance of raised figures rather than of depressions. This raised appearance is very striking when there is a combination of the plus and minus rhombohedron in parallel position and without overlapping, fig. 10 of Pl. V.

The figures vary considerably in size, but most of them are near 1 mm. in diameter. A few were observed that were nearly 2 mm. in diameter.

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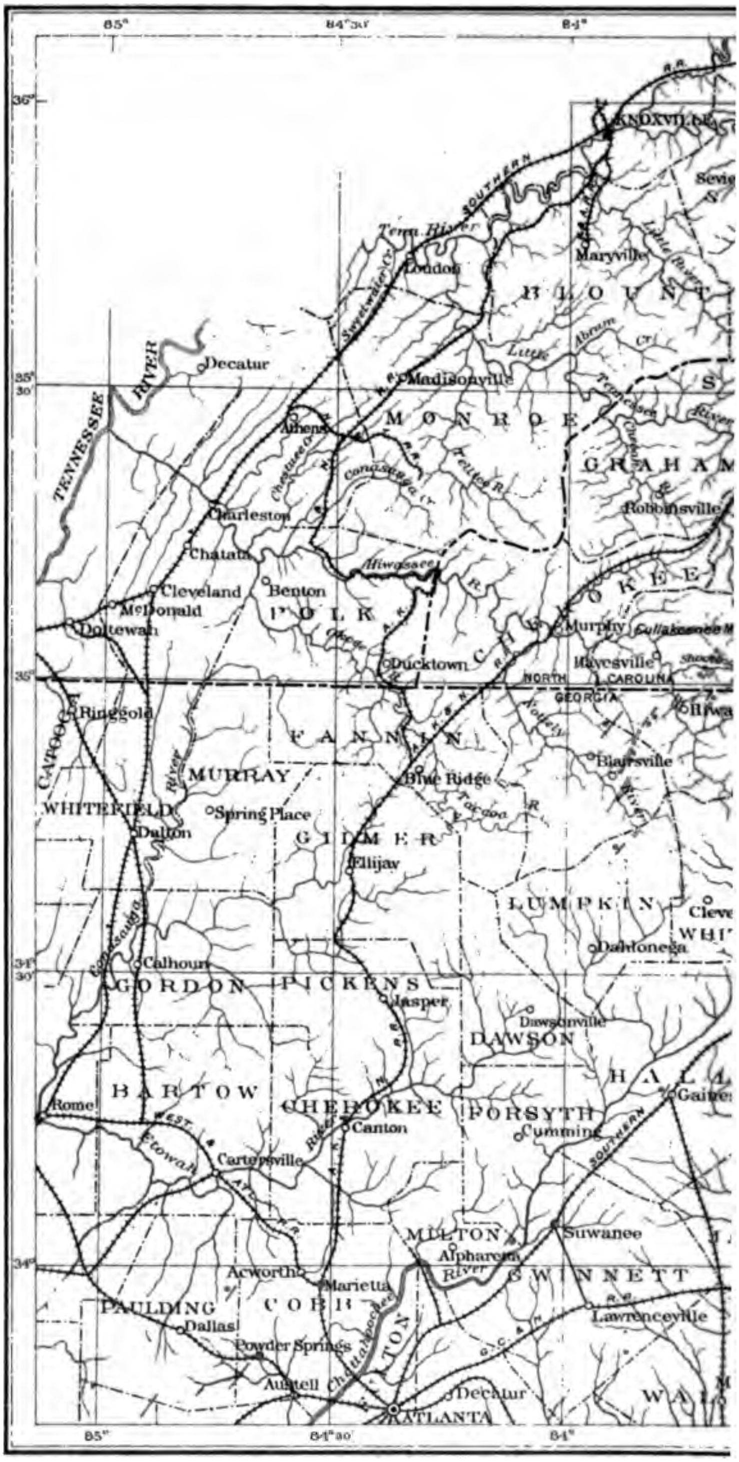
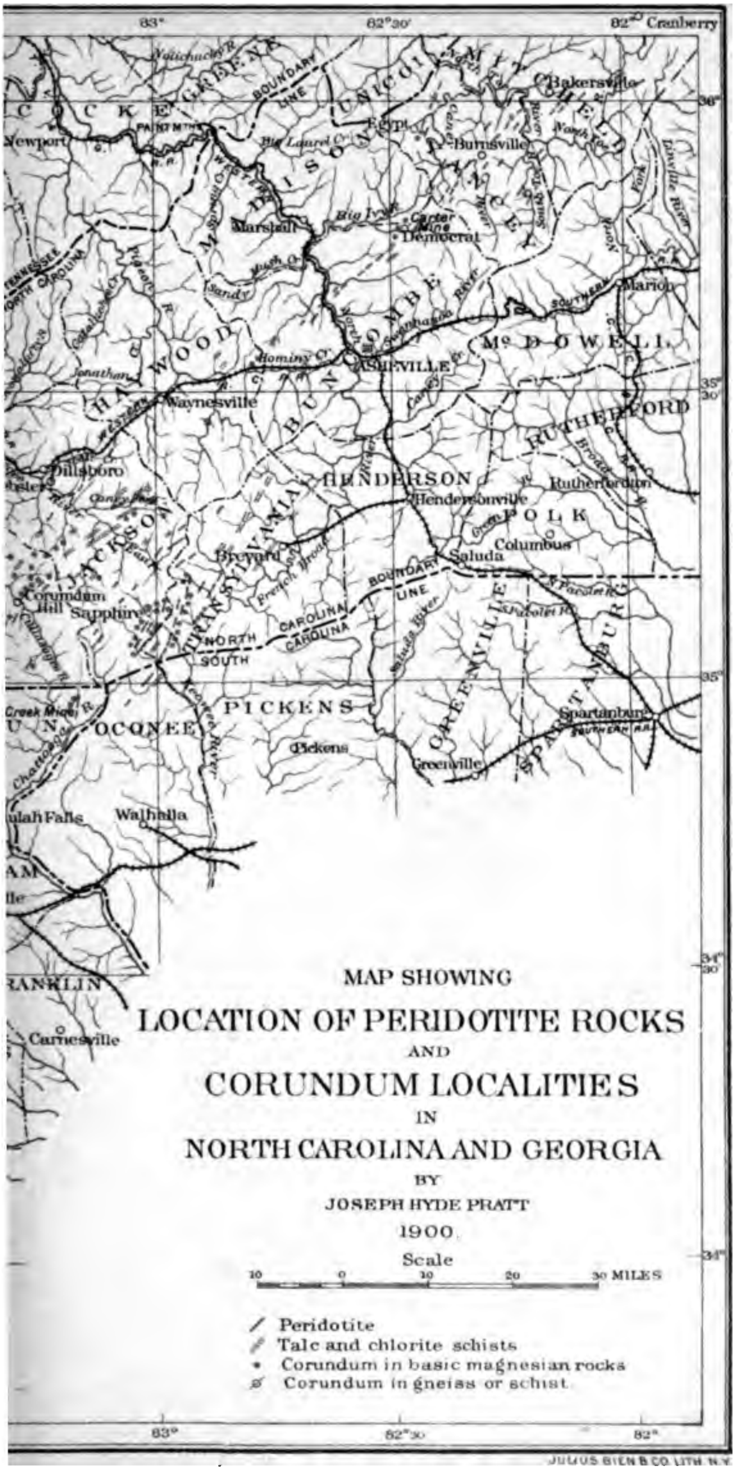
[1] Neues Jahrbuch für Min., Geol. und Pal., Vol. XI, 1896, p. 200.

[2] Am. Jour. Sci., 4th series, Vol. IV, 1897, p. 426.

U. S. GEOLOGICAL SURVEY





MAP SHOWING

LOCATION OF PERIDOTITE ROCKS

AND

CORUNDUM LOCALITIES

IN

NORTH CAROLINA AND GEORGIA

BY

JOSEPH HYDE PRATT

1900

Scale

/ Peridotite
⫽ Talc and chlorite schists
• Corundum in basic magnesian rocks
ø Corundum in gneiss or schist

JULIUS BIEN & CO. LITH. N.Y.

Bauer[1] has described etching figures that he observed on the base 0001 and the pyramid $22\bar{4}3$ of the Burma rubies. Those on the base are similar to the figures in fig. 5 of Pl. V, except that the outside contour of the rhombohedron is rounded.

These sapphire deposits are now controlled by the New Mine Sapphire Syndicate of Utica, Fergus County, Mont., and London, England, of which Mr. George A. Wells, of Great Falls, Mont., is president. Mr. S. S. Hobson, of Lewiston, Mont., one of the directors of the company, states in a recent letter that 130,000 carats of cuttable material were taken out last season. Besides this there is a large amount of very small crystals and badly flawed larger crystals that are not capable of being cut into gems and that are sold by the ounce. The largest rough stones that have been found weighed 11 to 12 carats, and from these were cut gems weighing 5 to 6 carats. One of the better stones taken out the season of 1899 weighed 4 carats when cut and is valued at over $75 a carat. All of the material is shipped to London.

That the American gems are being appreciated is shown by the large orders that are received for them from Paris, London, and New York.

CORUNDUM.

Under this head are included all the translucent to opaque varieties of all colors, subdivided into block, crystal, and sand corundum. While a sharp line can be drawn between corundum and emery, no such distinction can be made between corundum and sapphire, for many pieces of the former are found that have transparent portions. Many sapphire gems have been found in masses of corundum that were being mined for abrasive purposes.

In the following descriptions corundum deposits have been taken up by States in the order of supposed importance. Many of the beds are briefly noticed, but the larger and more important deposits are described in detail.

NORTH CAROLINA.

Most of the corundum localities in North Carolina are, in a general way, indicated on the map (Pl. VI), except the very few that are east of the Blue Ridge. In the following descriptions only those deposits have been considered which have been mined for corundum or which hold out a promising prospect for the mineral. These will be taken up by counties, the more important ones first.

MACON COUNTY.

Corundum was first discovered in this county in 1870 at what is now known as the Corundum Hill mine, and mining was begun here about a year later. This mine has become one of the most important corundum deposits in this country. It is situated about 8 miles southeast of Franklin, the county seat, on the northeast side of Cullasagee Creek, a tributary of the Little Tennessee River.

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[1] Loc. cit., p. 213.

The corundum found at this mine occurs in peridotite rock, and this has been worked very extensively, especially near the contact of this rock with gneiss. Pl. VII gives a general view of this peridotite formation, and shows to a certain extent the number of openings that have been made in it. The hill is about 350 feet high, the summit being about 500 feet above the level of Cullasagee Creek. Fig. 10 is a topographic map of this same peridotite formation, and shows the location of the various mines. The formation is a rather blunt lens-shaped mass of the dunite variety of peridotite, and has about 10 acres of surface, over most of which the rock is exposed. As is seen from this map, most of the mines are located near the contact of the dunite with the gneiss or schist, and follow contact veins of corundum. A number of dunite veins have been worked within the formation, but with the exception of the one marked "Shaft" on the map, they have all soon pinched out.

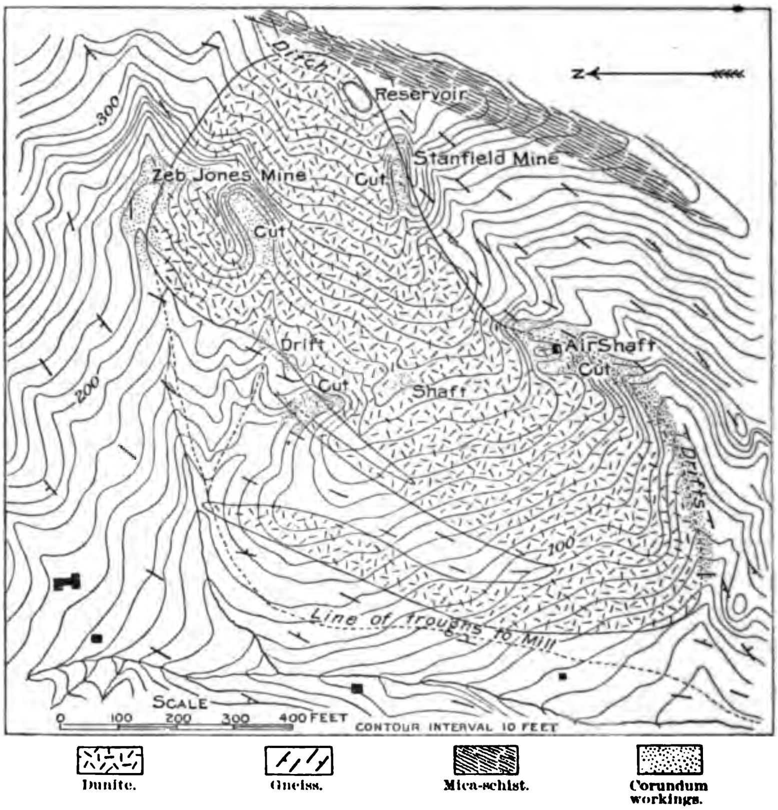
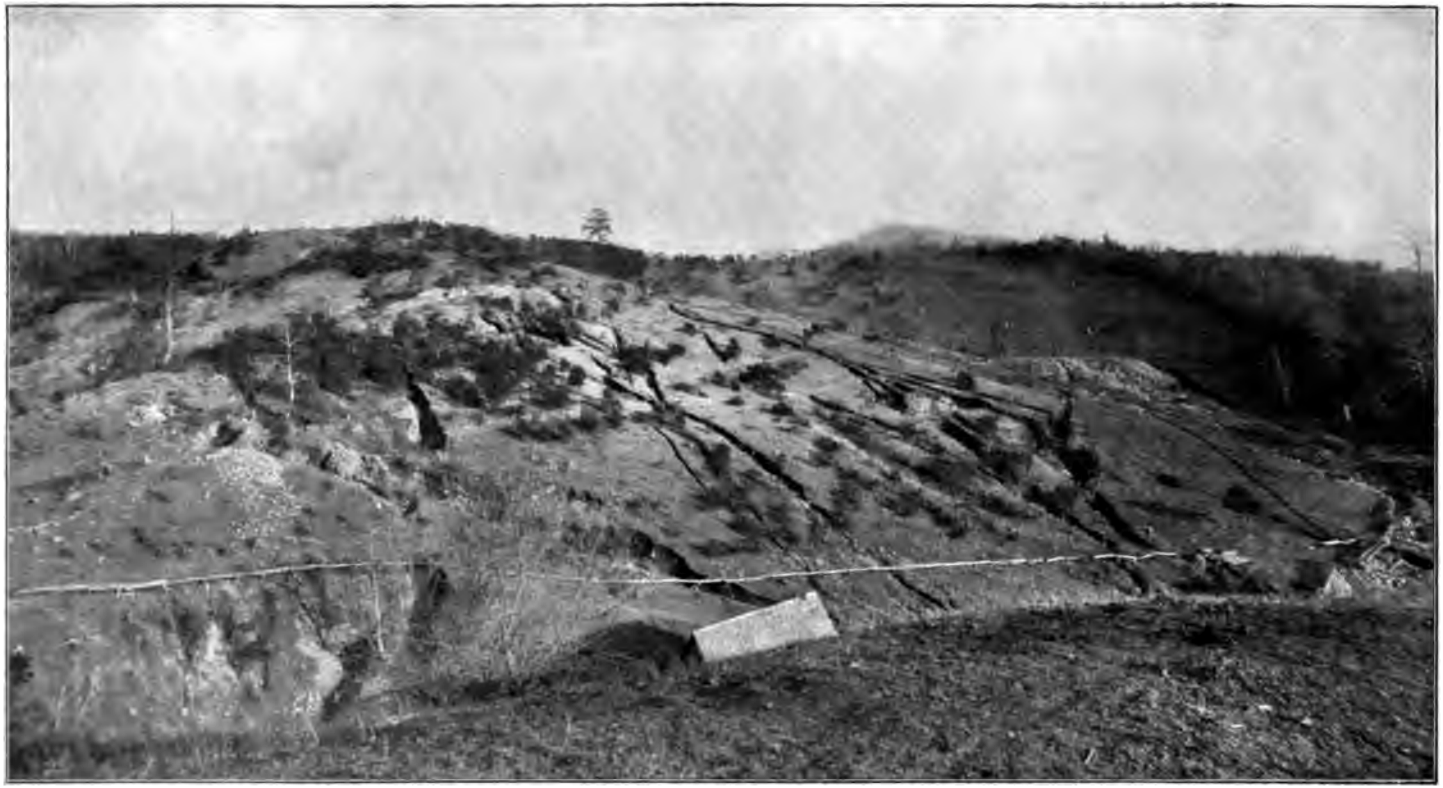
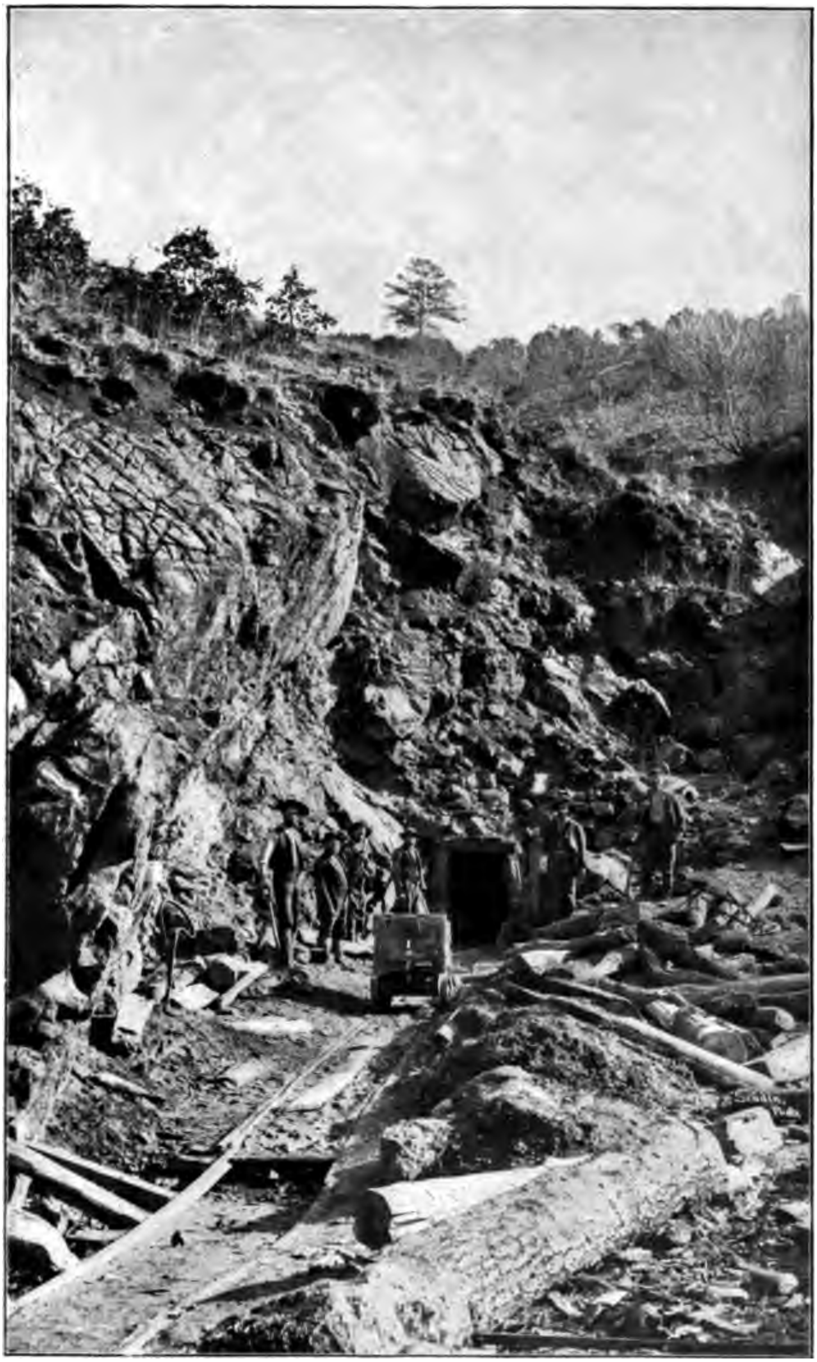


FIG. 10. Map of the peridotite formation at Corundum Hill, Macon County, N. C.



GENERAL VIEW OF THE PERIDOTITE FORMATION AT CORUNDUM HILL, MACON COUNTY, N. C.



THE BIG VEIN BETWEEN THE PERIDOTITE AND THE GNEISS AT CORUNDUM HILL, MACON COUNTY N. C.

Most of the mining has been done on the south side of the formation, where was encountered what is known as the Big vein. This was first mined by means of open cuts and later by tunnels, the last one being about 300 feet below the summit of the hill. Pl. VIII is a view of the entrance to this tunnel, and shows the peridotite rock on the left and the gneiss on the right beyond the cut. For nearly the whole distance of the southern boundary of the dunite formation a cut has been made following the contour of the hill. This cut was sometimes wholly within the gneiss, at other times wholly within the peridotite, and again cutting directly on the contact. The tunnels are all to the left of the cut, and they have encountered corundum almost continuously for a distance of 1,280 feet, reaching nearly to the southeast boundary of the formation. Pl. IX is a view of the upper or southeastern end of this cut, showing the peroditite on the left and the gneiss and schist on the right. The upper part of this cut is known as the Stanfield mine. A tunnel has been run into the hill near the contact, at the head of which the vein of corundum is 8 to 10 feet wide. No work has been done at this mine for a number of years.

On the northeast side of this formation is what is known as the Zeb Jones mine, where there was exposed (July, 1899) a bench of ore 25 feet in depth and 2 to 5 feet in width, uncovered for a distance of 50 feet, which averaged very close to 50 per cent corundum. This vein carries what is known as "buckwheat" corundum, which, as its name suggests, is made up of small, irregular particles of corundum about the size of buckwheat grains.

Numerous dunite veins have been found and worked, but they can be mined profitably only when they are large contact veins, for the reason that they are very likely to pinch out after being worked for a short time.

From these various openings, collectively known as the Corundum Hill mine, block, crystal, and sand corundum ores have been obtained, all of which can be readily cleaned and will make a commercial product that can be used in the manufacture of any kind of corundum wheel. A small amount of garnet is occasionally found associated with the corundum in the vein along the southern contact, but this portion of the ore can be readily eliminated by hand cobbing at the mine. This is the only mine that produced any quantity of corundum during 1899. It is now owned by the International Corundum and Emery Company, of New York, N. Y.

The water of Cullasagee River is utilized for the washing and cleaning machinery of the mill, which is located about a mile and a half below the mine, at Cullasagee. A line of sluice boxes connects the mine with the mill, and all the corundum ore that can be readily broken to pieces is carried down to the mill in these boxes.

There are many outcrops of peridotite on Ellijay Creek, a few miles north of Cullasagee, and at many of them corundum has been found.

The most work that has been done is at the Mincey mine, which is 2 miles northwest of the Corundum Hill mine. At this locality a considerable quantity of corundum has been taken out, which was carried to the mill at Cullasagee and cleaned. Pl. X is a view of this open cut, which was entirely within the formation. Judging by the amount of corundum obtained and by that found near the contact of the dunite with the gneiss, there are good indications of the existence of corundum in quantity along the contact. The corundum that was obtained at this mine was hauled by wagons to the Corundum Hill mine, where it was cleaned. This property is owned by the International Corundum and Emery Company, of New York, N. Y.

Between the Corundum Hill and Mincey mines there is a bold outcrop of dunite on the Gray property, covering about the same surface as that at Corundum Hill. Although there has been no mining here, the little prospecting that has been done has shown corundum to be very thickly scattered along the lower borders of the formation, and many small pits that have been sunk within the formation have encountered corundum. This, in my opinion, is one of the most promising prospects for corundum in Macon County.

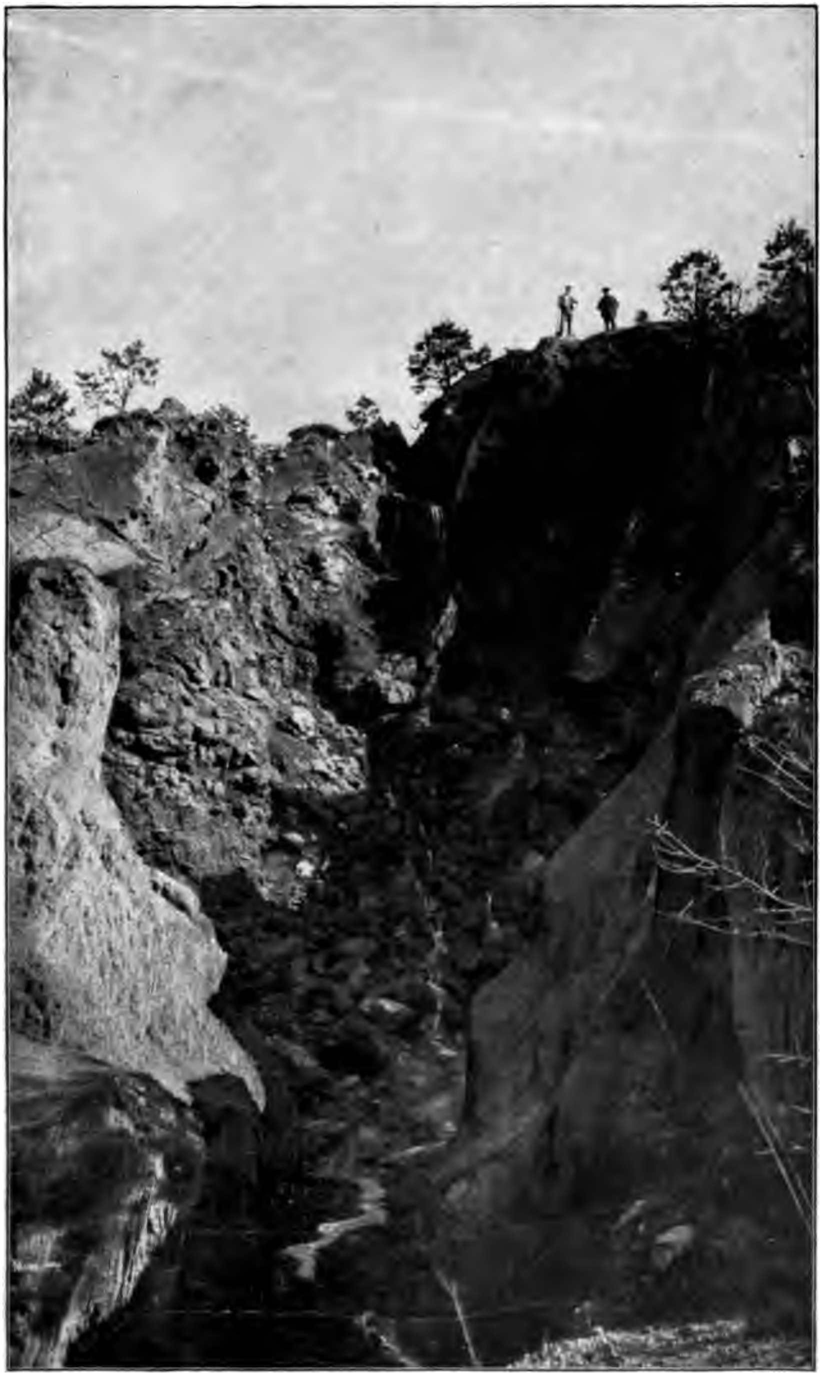
A great many of the peridotite formations along Ellijay Creek have been worked a little at different times, and these are mentioned in the lists of corundum localities (p. 83).

Sheffield mine.—This mine is in Cowee Township, about 7 miles northeast of Franklin, the county seat, just north of Cowee Creek. The corundum occurs here in amphibole-schist, and is described on page 31. On account of the depth to which decomposition has extended, the solid rock was only observed in the lower portions of the 87-foot shaft, so that nothing definite is known of this corundum-bearing amphibole-schist. The corundum, which is pink in color and which occurs in oval-shaped nodules up to an inch in diameter, has been pretty thoroughly mined down to the hard rock. The corundum is of good quality, and some preliminary tests have shown that it is well adapted to the manufacture of the vitrified wheel. On account of the low percentage of corundum in the rock, it is not at the present time a profitable corundum ore.

The saprolitic ore is readily cleaned, and furnishes a nearly pure commercial product. A small mill has been erected here. This property is owned by the National Abrasive Manufacturing Company, of New York, N. Y.

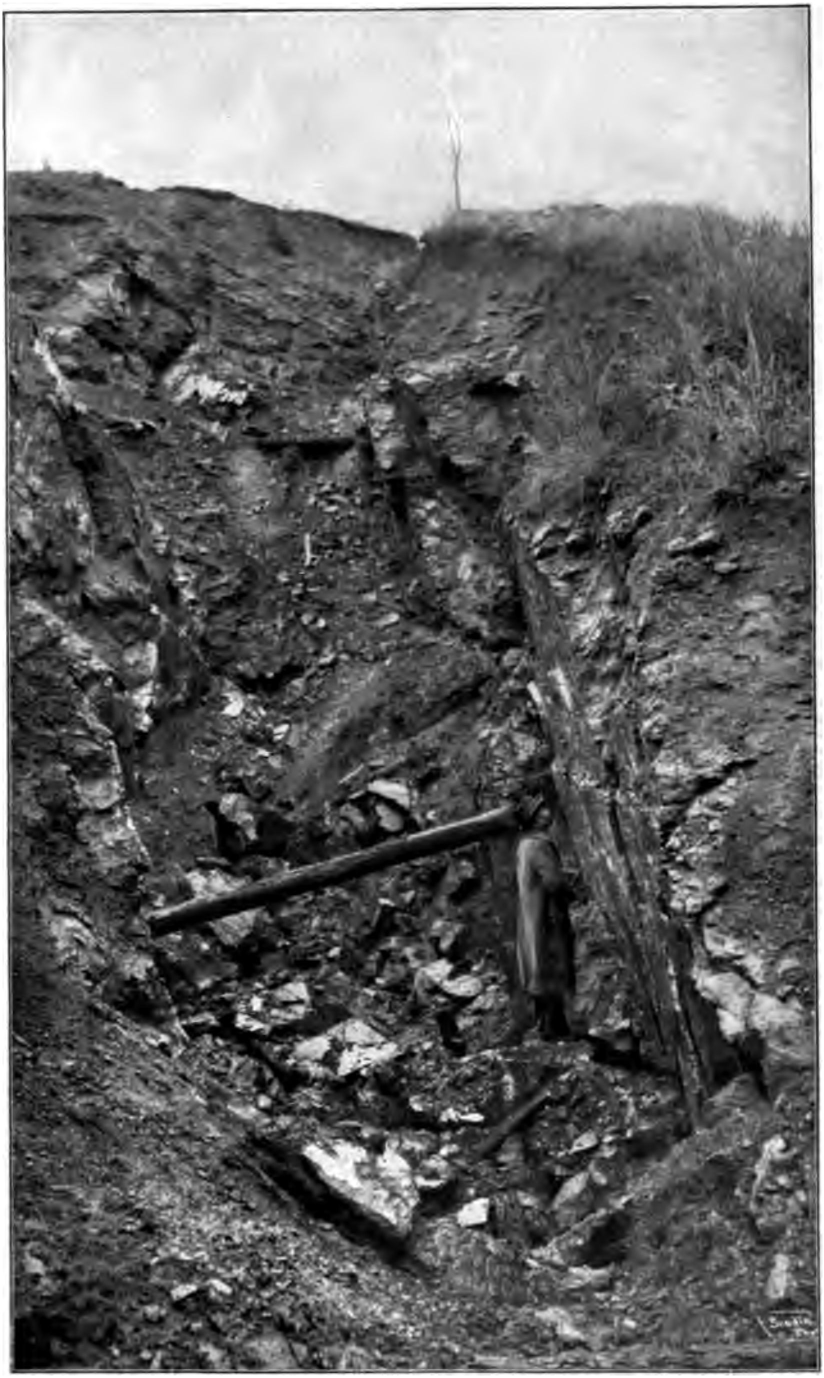
CLAY COUNTY.

Buck Creek or Cullakeenee mine.—This mine is in the Buck Creek Valley, about 20 miles southwest of Franklin, Macon County, and 21 miles a little north of east of Hayesville, the county seat of Clay County. These corundum deposits are associated with a compact mass of peridotite, covering about three-quarters of a square mile, the largest



UPPER END OF BIG CUT AT CORUNDUM HILL MINE, MACON COUNTY, N. C.

Peridotite is shown on the left and gneiss and schist on the right.



OPEN CUT ON DUNITE VEIN AT THE MINCEY MINE, MACON COUNTY, N. C.

mass that is known in the Appalachian belt. Fig. 5 (page 22) is a topographic map of this formation, and shows the relation of the amphibolite to the peridotite and the location of the various openings that have been made for corundum. There has been but very little systematic mining for corundum in this locality, and most of the work has been in the nature of prospecting. Numerous cuts and pits have been made at a great many points on the formation, most of which have shown the presence of corundum. The principal work is at the east end of the formation, near the contact of the dunite with the gneiss, where a shaft 40 feet deep was sunk partially on the contact vein. A number of open cuts in this same vicinity have penetrated into the same vein. This vein is different from most of the corundum veins in the peridotite rocks, in that it is composed essentially of plagioclase feldspar and hornblende, which bear a similar relation to each other as the feldspar quartz and mica in the pegmatitic dikes. Pl. XI, *A*, is a general view of the Buck Creek formation, showing the shaft mine and the location of the contact vein that has been opened. With this exception all the pits and cuts that have been made are within the formation itself, and where they encountered corundum it was in small pockets, the remains of larger dunite veins. Pl. XI, *B*, shows one of these dunite veins. From the amount of corundum exposed by prospecting and the work done in the shaft, there is without doubt a large amount of corundum associated with these peridotite rocks, and if the mine were more accessible to the railroad it would offer one of the best corundum prospects in the country. At the present time, however, the nearest shipping point is Murphy, which is over 40 miles to the west. The nearest point on the Murphy branch of the Southern Railway is only 18 miles, to which a good road can be built that would not cost much more than the first 18 miles of the road to Murphy. Buck Creek offers ample water supply for running a mill sufficient to clean whatever corundum would be mined here. This property is also owned by the International Corundum and Emery Company, of New York. The ore is not difficult to clean, and, as far as can be judged from a superficial examination, should make a commercial product that can be used in the manufacture of the vitrified wheel.

Blue Ridge corundum tracts.—Under this head are included the long bands of corundum-bearing quartz-schist that have been found in the southeastern part of the county and in the adjoining county of Georgia (Rabun County). Parallel bands of this corundum-bearing schist have been followed for a number of miles close to the summit of the Chunky Gal and the Yellow mountains. As is stated on page 35, the amount of corundum in this schist is probably not over 5 per cent, and with such a low percentage of corundum these rocks are not to be considered, at the present time at least, as a source of this mineral.

There are four tracts included under this head, which are described below.

The Scaly Mountain tract is near the headwaters of Beech Creek, a prominent eastern tributary of the Tallulah River, on the southern and southwestern slopes of Scaly Mountain, at the elevation of about 4,500 feet. The corundum-bearing bands of schist have been traced for the distance of about 2 miles, with a general strike of N. 40° E. and with a dip approximately 20°–30° NW. Considerable prospecting has been done in tracing this band of schist, but experiments show that there is less than 5 per cent of corundum in this schist, although some specimens have yielded 12 per cent. The latter were probably pieces broken off along planes of lamination of the schist, while the rest of the piece from which they were broken off carried but little corundum.

The Foster tract is in Georgia, about 1¼ miles from Scaly Mountain, and the State line forms its northern boundary. It is on both sides of Falls Branch, one of the smaller western tributaries of the Tallulah River, and is about 3,500 feet above sea level. Here a number of pits have been made and samples of corundum have been obtained which have assayed on an average about 5 per cent of this mineral. There is more garnet associated with the corundum in this ore than in that from any of the other localities.

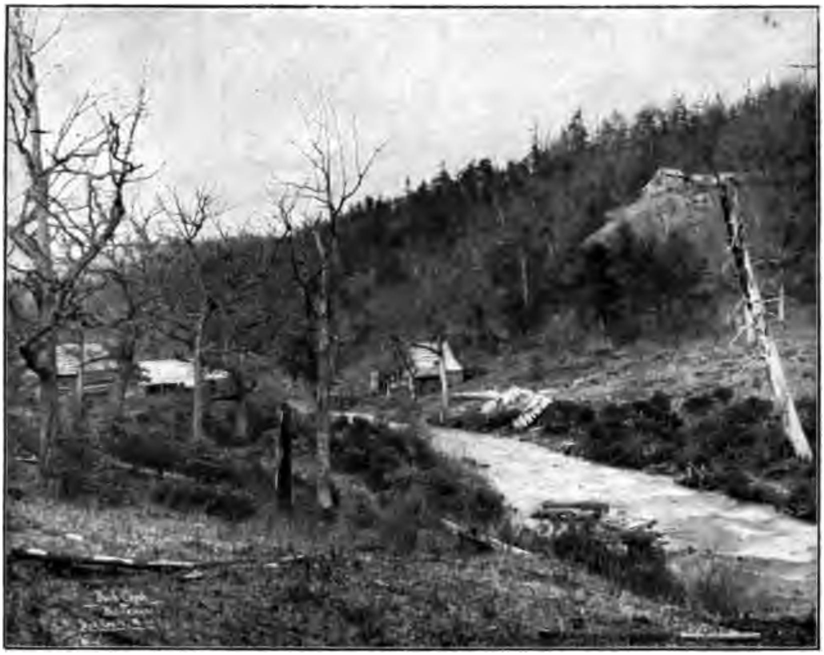
The Yellow Mountain tract is on the north of Scaly Mountain, on the northern slopes of the Yellow Mountains. No prospecting has been done here, and from the indications the ore is the same grade as at the other localities.

The Chunky Gal tract is at the summit and along the western slopes of the Chunky Gal Mountains, near the headwaters of Sugar Cove Creek. With a few interruptions, the corundum-bearing schist has been traced for over 2 miles, with a strike and dip approximately the same as on the other tracts. A number of pits and cuts have been made, from which considerable ore has been taken out and tested, and the tests show the percentage of corundum to be practically the same as at the others.

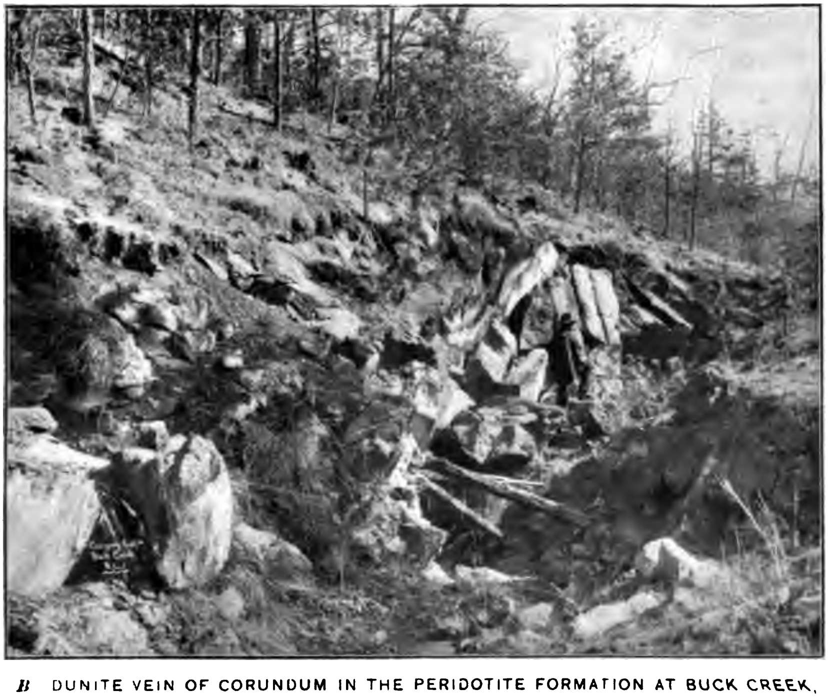
The corundum bands of the schist in all the tracts vary considerably in width, some being not over a foot or two wide, while others are 18 feet. In these wider bands, however, there are apt to be bands of the normal schist. More or less garnet has been found associated with the corundum in all the schist, and if in any amount would have to be eliminated or it would prevent any commercial corundum obtained from these ores being used in the manufacture of the vitrified wheel.

From the extent of the corundum-bearing schist, there is undoubtedly a large quantity of corundum in this section, but the low percentage of corundum in the rocks makes it very questionable whether they can be profitably worked.

The Corundum Mining and Manufacturing Company, of Philadel-



A GENERAL VIEW OF THE BUCK CREEK CORUNDUM MINE AND PERIDOTITE FORMATION, CLAY COUNTY, N. C.



B DUNITE VEIN OF CORUNDUM IN THE PERIDOTITE FORMATION AT BUCK CREEK, CLAY COUNTY N. C.

phia, Pa., has recently been organized to work the deposits on the Scaly Mountain and Foster tracts. The only mining that has thus far been done consists of an open cut extending 35 feet on the band of corundum-bearing quartz-schist. About 1,000 tons of ore have been taken out, a small portion of which has been crushed and cleaned. The point at which mining was begun is on the southwestern slopes of Scaly Mountain at an elevation of nearly 4,500 feet. The crushing plant has been erected close to the cut. The cleaning mill is about 2,000 feet lower on Scaly Mountain, the crushed ore being conveyed thither in a flume.

No definite method of cleaning has as yet been decided upon. Experiments have been made with jigs and a Bartlett table, but they have not proved very satisfactory. The garnet and magnetite in the ore are to be separated by the electro-magnet. No corundum has as yet been cleaned for the market.

JACKSON COUNTY.

Perhaps the most important corundum locality in this county is in the extreme southeastern portion, in the vicinity of Sapphire, extending over into the adjoining county, Transylvania. In this section there is a series of about 30 outcrops of peridotite, which extend in a general northeast-southwest direction. All these outcrops are small, and corundum has been found associated with many of them. The location and relative size of the larger of these outcrops and the places where corundum has been mined are represented on the map, fig. 11. Most of this has been at the Bad Creek and Socrates mines, but the greater part of the work done at any of them has been in the nature of prospecting.

At the Burnt Rock mine, which is located about 5 miles northeast of Sapphire, all the mining has been done within the peridotite formation, and about 10,000 to 12,000 pounds of corundum have been taken out. It is of good quality and occurs in white crystals and knotty nodules. The ore is free from garnet and can be readily cleaned. From the amount of work done here the indications are that there is a considerable quantity of good corundum associated with the peridotite near its contact with the gneiss. The mining at the Brockton mine was also within the peridotite, and about the same amount of corundum was taken out as at the Burnt Rock mine. The corundum occurs in dull-gray crystals, which are easily cleaned and separated from the gangue. These two mines are in Transylvania County. Just below this mine, on the slopes of Poplar Ridge, a vein of corundum was exposed in October, 1900, by workmen who were making a new road. The corundum is massive, and gives good indications of occurring in quantity.

The little work that was done at the Sapphire mine shows a considerable quantity of white and gray corundum, often speckled with blue, very similar to the corundum found at the Whitewater mine, 6 miles south of the Sapphire mine. The Socrates mine is about three-quarters of a mile southwest of the Sapphire, in a bold outcrop of peridotite. The corundum is in small, knotty nodules and is easily cleaned. A contact vein was encountered, but little work was done to develop it.

The Bad Creek mine has been worked more than any other in this section, and is located about three-quarters of a mile nearly south of Sapphire. The work done at this mine has been almost entirely on a contact vein which has been exposed for the distance of 130 feet and has been worked at one point to a depth of 60 feet. The corundum ore that was encountered in this vein is of two distinct kinds; in one the corundum is associated with garnet and hornblende, and in the other, which is free from garnet, the corundum is in a matrix of biotite-mica. These two ores should always be kept separate, for the corundum can readily be cleaned and separated from the associated minerals in the biotite ore and will yield a product that can be used in the manufacture of the vitrified wheel; but the corundum can be separated only with difficulty from the ore that contains the garnet. Unless

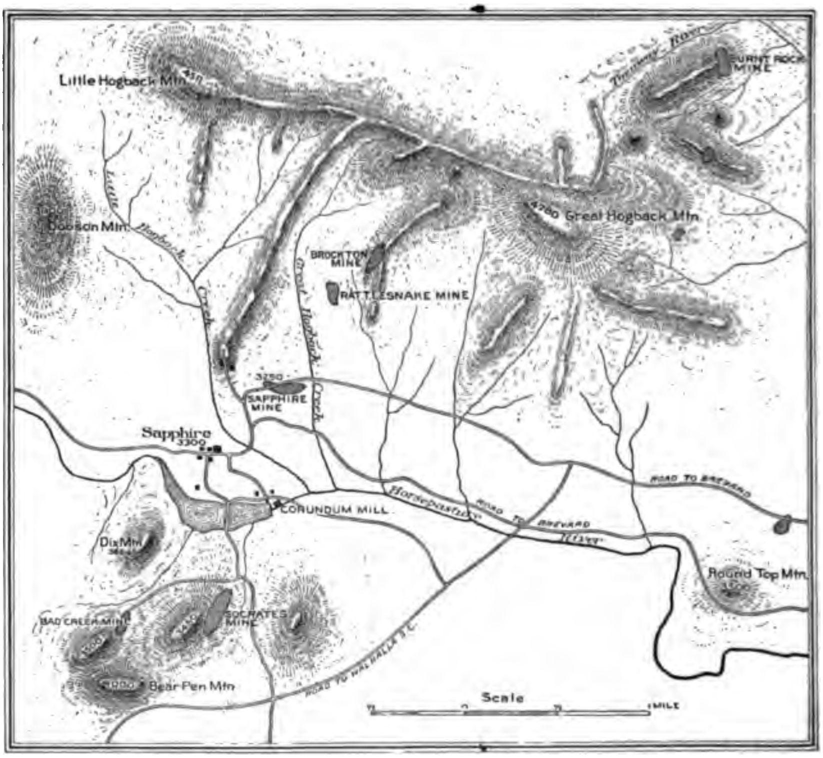


FIG. 11.—Map of the peridotite areas in the vicinity of Sapphire, Jackson County, N. C., showing the location of the different corundum mines.

he garnet can be entirely eliminated this ore will not make a product hat can be used for making the vitrified wheel. The vein has an average width of nearly 9 feet, and will carry from 15 to 20 per cent of corundum. All these mines just referred to belong to the Toxaway Company, Sapphire, N. C.

Corundum has been found at a number of the peridotite outcrops between the Bad Creek and the Whitewater mines; and while this loes not by any means indicate that there are large deposits of this nineral in these rocks, it does indicate, taking into consideration the corundum deposits already found northeast and southwest of these, hat there is a possibility of such deposits, and it makes this section a promising one for systematic prospecting.

GEORGIA.

The corundum localities of this State are shown on the map (Pl. VI), which also gives the general location of the peridotite formations that have been observed in this section. Although there is considerable peridotite occurring in the northern portion of the State, it is at but ew places thus far that corundum has been found in any quantity, and these are at the extreme northern part, not far from the North Carolina line.

Georgia corundum is well known, and perhaps has the best reputaion of any on account of that obtained from the Laurel Creek mine, which, with the exception of the Track Rock mine, is the only one hat has produced any considerable quantity of corundum. The peridotite formations are not so large as in North Carolina, nor are he corundum localities so numerous, and it is not probable that there s as much corundum in this State as in North Carolina, although he Laurel Creek mine may be superior to any one thus far located n North Carolina.

Laurel Creek mine.--This mine, which is owned by the International Corundum and Emery Company, is located at Pine Mountain, Rabun County, Ga., and is 18 miles from Walhalla, S. C., the nearest point on the railroad. At this locality there is a large outcrop of peridotite, covering several hundred acres, and along the contact of this with the gneiss large deposits of corundum have been found. Several openings have been made, some of which have been worked very extensively. Fig. 12 is a topographic map of this peridotite formation, showing the general location of the cuts and shafts that have been made. As is seen from the map, the formation extends over two small hills, which, on account of their rough and barren nature, offer a sharp contrast to the surrounding country. There is a large open cut (1 in fig. 12) on the east side of the formation, which follows for the most part along the contact, is 200 feet in depth at the lower end, and gradually rises until at the upper end the surface is reached.

At its lower end this cut encountered what is known as the Big vein of massive corundum, the cut having followed on a contact vein of crystal corundum. Pl. XII is a photograph of this cut, which shows the gneiss very distinctly on the left and the peridotite on the right, with the shaft house in the foreground.

The Big vein of massive corundum, for which this mine is noted, is at the foot of the south slope of the hill, and has been followed from the lower end of the cut (1, fig. 12) for a distance of over 300 feet, represented by the dotted lines, with the shaft house (4, fig. 12) near the western end. Although this vein is near the contact of the peridotite with the gneiss, it is separated from it by a band of peridotite and a small vein of sand corundum. There is some doubt whether the block of gneiss (2, fig. 12) is entirely surrounded by the peridotite or whether it penetrates the peridotite from the main mass of gneiss. From what could be seen, and from information obtained from Mr. Andy Evans, foreman of the mine, it has very much the appearance of being entirely inclosed in the mass of peridotite. The Big vein, which has been worked by an inclined shaft 116 feet deep, with tunnels 300 feet in length running from this, has brought the work up to the block of gneiss just referred to, and, according to Mr. Evans,

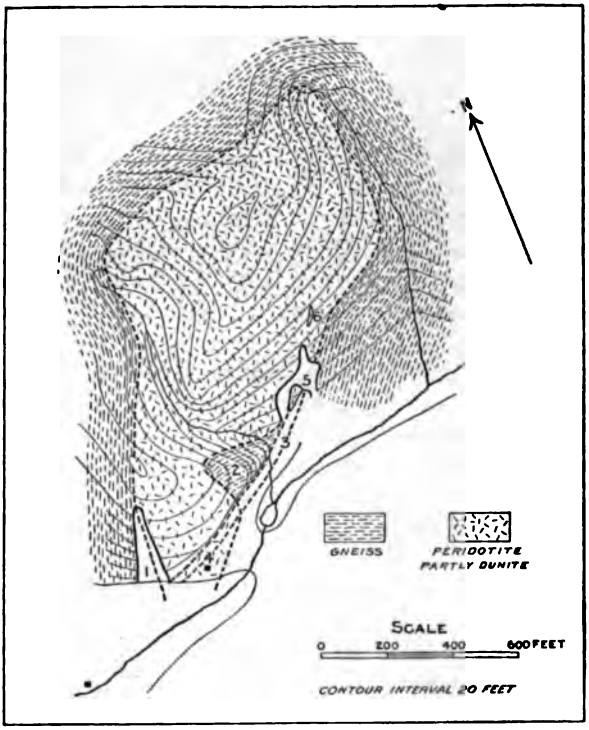
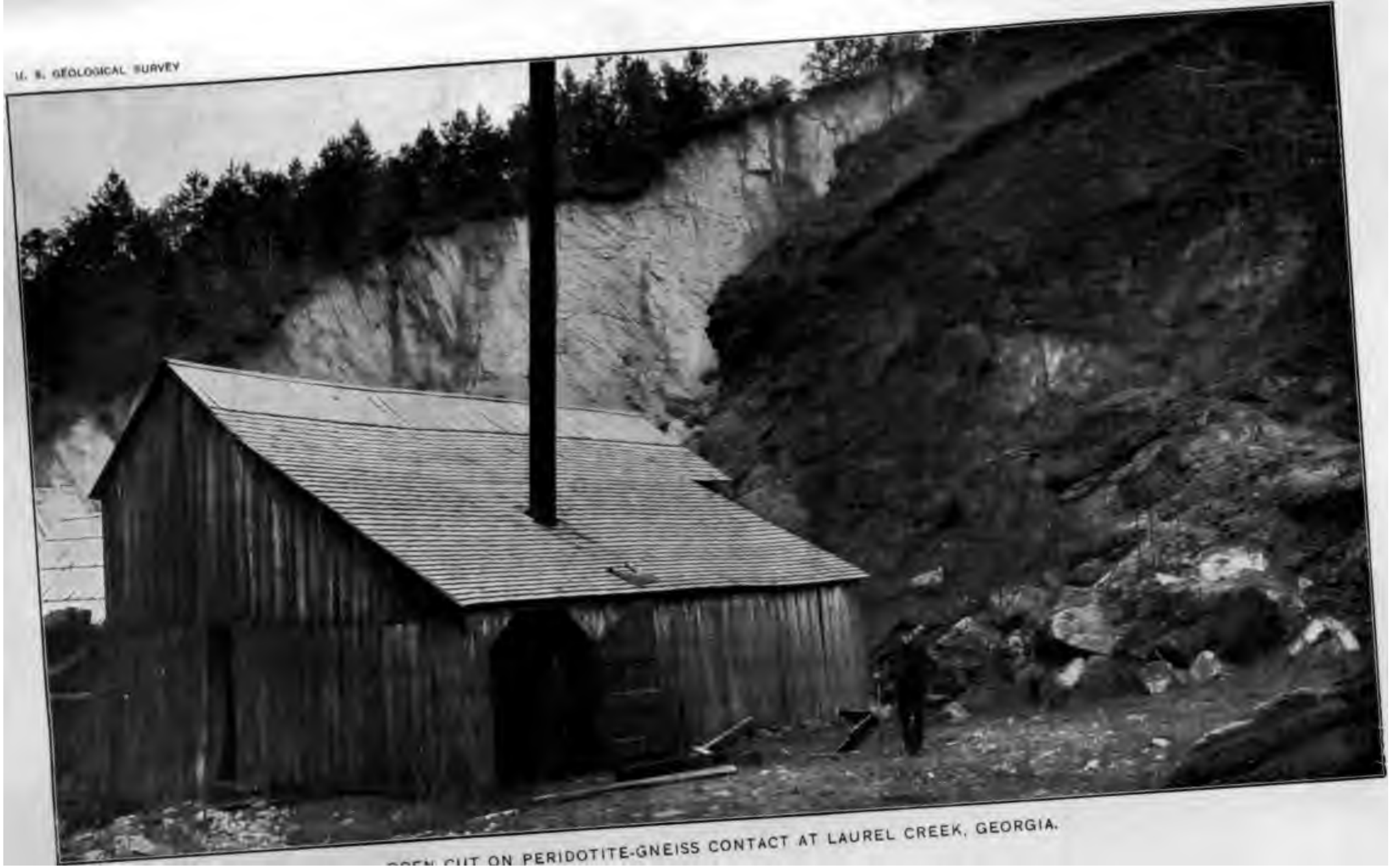


FIG. 12.—Map of the peridotite formation at Laurel Creek, Rabun County, Ga.



OPEN CUT ON PERIDOTITE-GNEISS CONTACT AT LAUREL CREEK, GEORGIA.

SOUTH CAROLINA.

In the northeastern part of York County, from 3 to 4 miles west of the Catawba River, on the land between Allison and Crowder creeks, corundum has been found in a belt about 200 to 300 yards wide which skirts along the western slopes of Nannies Mountain. This locality is about 12 miles northeast of Yorkville, S. C., and 25 miles southwest of Charlotte, N. C.

Mining operations have been carried on at two distinct portions of this belt, one a mile north of the summit of Nannies Mountain, on the property of Alexander Rickard. The work done here consists of a shaft about 35 feet deep, from which several drifts have been run, which penetrate what is probably a light-gray granite, but it is much decomposed and of a sandy constituency. The only solid material encountered were irregular masses of black cleavable corundum associated with muscovite mica. In the surrounding fields float corundum ranging in size from small particles to masses of several pounds in weight are abundant, and many tons of this have been picked up and shipped.

A little to the west of the south end of Nannies Mountain, about 1½ miles from the Rickard mine, there is a similar occurrence of corundum. There have been a number of shallow cuts, ditches, and pits made in prospecting for corundum, but apparently none was found in place. The corundum that was found is often wrapped in mica.

The mode of origin of this corundum has not been determined, for up to the present time the exact nature of its occurrence is not definitely understood, as no exposure of the corundum can be seen which shows its relation to the rock in which it occurs. Neither can it be stated whether it is to be found in quantity.

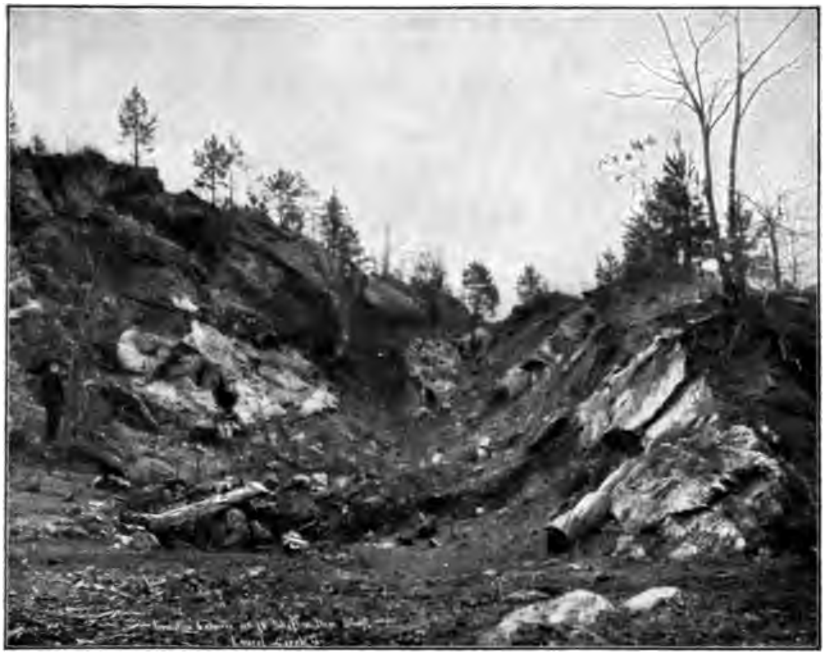
PENNSYLVANIA.

The corundum in this State, so far as can be learned, is all associated with the serpentine rocks in Chester and Delaware counties and occurs near the contact of this rock with the gneiss. Considerable feldspar (plagioclase) similar to that described from the Big vein at Buck Creek, N. C., is usually crystallized out with the corundum.

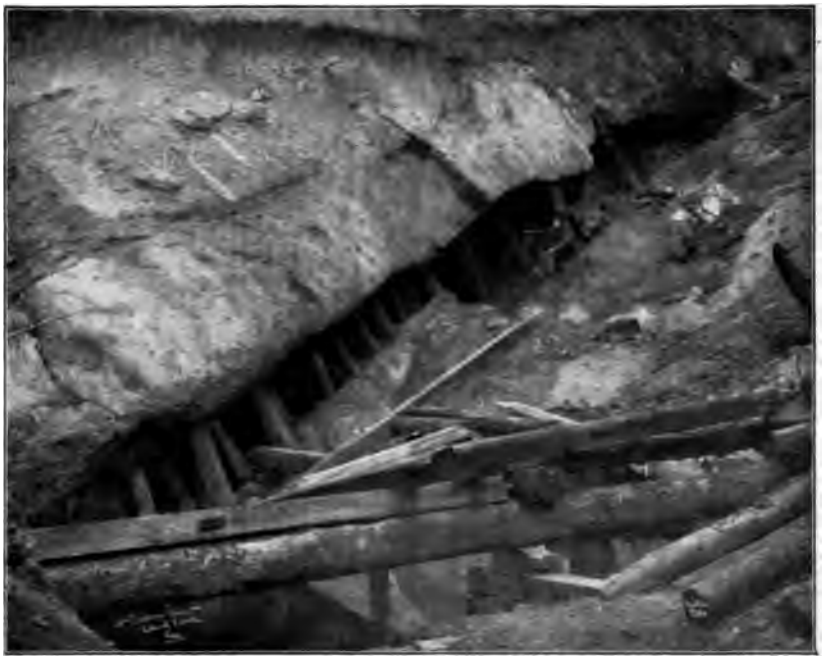
Corundum has been found more abundantly near Unionville, in Newlin Township, Chester County. It is found here in a mass of serpentine rock, with an average width of about 800 feet and a length of 1 mile. A number of tons of corundum have been obtained from this mine, but during the last ten years little or no work has been carried on here. Associated with the corundum are tourmaline and spinel.

MONTANA.

Most of the corundum that has been found in Montana has been of *the sapphire* variety, but at one locality near Bozeman, Gallatin



A PERIDOTITE FORMATION AT LAUREL CREEK, GEORGIA.



B DUNITE VEIN OF CORUNDUM AT LAUREL CREEK, GEORGIA.

a little work was done farther to the east which showed the corundum vein to extend on the south side of the block of gneiss, and it is not at all improbable that this vein continues as represented by the dotted line 3. Open cuts on the east and west side of this block of gneiss have followed contact veins of corundum. Pl. XIII, *A*, is a photograph of the peridotite formation near the cut on the east side. Little work has been done at Laurel Creek except on contact veins, the principal exception being a small dunite vein (6 in fig. 12) near the west end of the formation, from which considerable corundum was obtained, but the vein soon began to pinch out. Pl. XIII, *B*, is a photograph of this vein, showing both the hanging and foot walls of peridotite. At 5, fig. 12, considerable work has been done, and some large crystals, for which this mine is noted, were obtained here.

This is perhaps the most famous corundum mine in this country, and has furnished ore from which an exceptionally good commercial product has been obtained.

It has not been worked since 1894, when the tunnels and shafts of the Big vein were cut off by the slipping of a large block of the peridotite formation, nearly a 200-foot cube. It is that portion of the formation represented on the map (fig. 12) between the open cut (1) and the cut to the west of the block of gneiss (2).

Track Rock mine.—The location of this mine is in the northeastern part of Union County, Ga., on the south side of Track Rock Gap. The corundum occurs in a peridotite formation, which is very much decomposed on the surface, there being very little visible but a mass of chlorite-schist containing more or less actinolite. A tunnel, having its upper end 75 feet below the surface, has been run in on the formation for about 200 feet, with short branching tunnels at several points. From the material cut through by the tunnel, which was examined by King,[1] of the Georgia geological survey, the rock was found to be an altered peridotite, made up of small grains of chrysolite surrounded by actinolite, and containing many grains of magnetite. It may be that the original of this rock was the peridotite amphibole-picrite.

All the work that has been done at this mine has been entirely within the formation, and the best results would be obtained near the contact of this rock with the surrounding country rock.

Foster mine.—This mine, which is located in the northeastern part of Towns County, Ga., just over the North Carolina line, has been described with the other mines occurring in this vicinity under the head of "Corundum in North Carolina," on page 60. The corundum occurs in a quartz-schist, and the property is owned by the Corundum Mining and Manufacturing Company, of Philadelphia, Pa.

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[1] Bull. Geol. Survey Georgia No. 2, 1894, p. 93.

average depth of 20 feet for the entire distance. Emery varying in width from 3 to 20 feet was encountered throughout nearly the entire length of the cut.

This mine was reopened in 1899, a shaft 87 feet deep having been sunk on the vein near the southern end of the cut and drifts run out from this. Margarite is the most conspicuous accessory mineral, and specimens that can rarely be excelled have been found here.

Continuing nearly half a mile to the north on the vein and near the top of the mountain is the Melvin mine. There is a shaft here 40 feet deep, from which drifts are being run. This shaft is but 1,250 feet from the head of the upper tunnel of the Old mine, the next one to the north. It is in this Old mine that the most extensive work has been done. Fig. 14 is a cross section of its underground workings. The mouth of the lowest tunnel is but 8 feet above Walker Brook and 75 feet to the south of it. As is seen from the diagram, the emery does not occur continuously throughout the vein, but in pockets or chimneys which dip into the vein about 30° N. From the work already done these seem to hold this direction rather constantly, so that the pockets can be approximately located at a given depth. It was in the first chimney of emery (see map, fig. 13) that the beautiful specimens of diaspore, for which this mine is noted, were found.

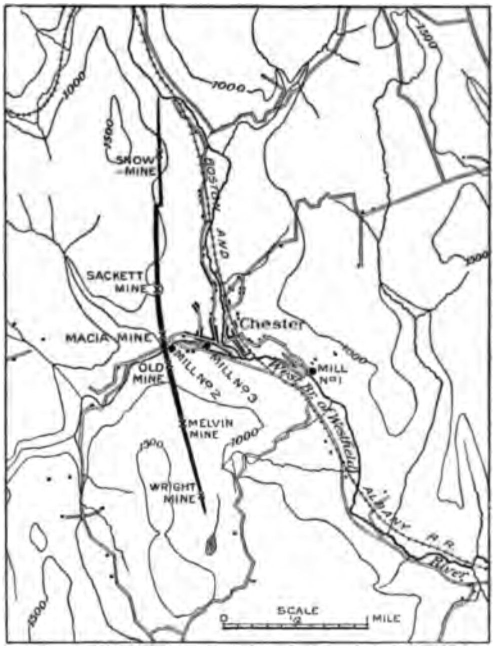

FIG. 13. Map showing the location of the emery deposit at Chester, Mass.

North of Walker Brook and about 500 feet from the Old mine is the Macia mine, where a small amount of surface work has been done. Near the head of a small ravine a tunnel was started on the west of the vein to intercept it, but work was discontinued before the vein was reached.

The next opening is near the highest point of the vein on the eastern slope of Gobble (North) Mountain, about three-fourths of a mile north of the Macia mine, and is known as the Sackett mine. At this part of the vein there was a considerable quantity of magnetite that was practically free from corundum and was mined as an iron ore. This mine was worked very extensively over twenty years ago, but had been abandoned until 1899, when it was reopened. The old works were near the highest point of the vein, on the slope of the mountain, and were worked for about 30 feet. The new work was started 117 feet below the mine, and a tunnel from the east side was run 114 feet to the vein. When this was reached a shaft and tunnels were started. At this mine the corundum occurs in what might be called porphyritic crystals of a bronze color, which are from 5 to 15 mm. across. Here blue and white masses of corundum weighing several pounds have been found, and small, well-formed blue crystals are also frequent. A little north of this mine, in an old opening, a cross vein of chlorite was encountered which carried a great many almost perfect cubes of pyrite and radiating groups of black tourmaline.

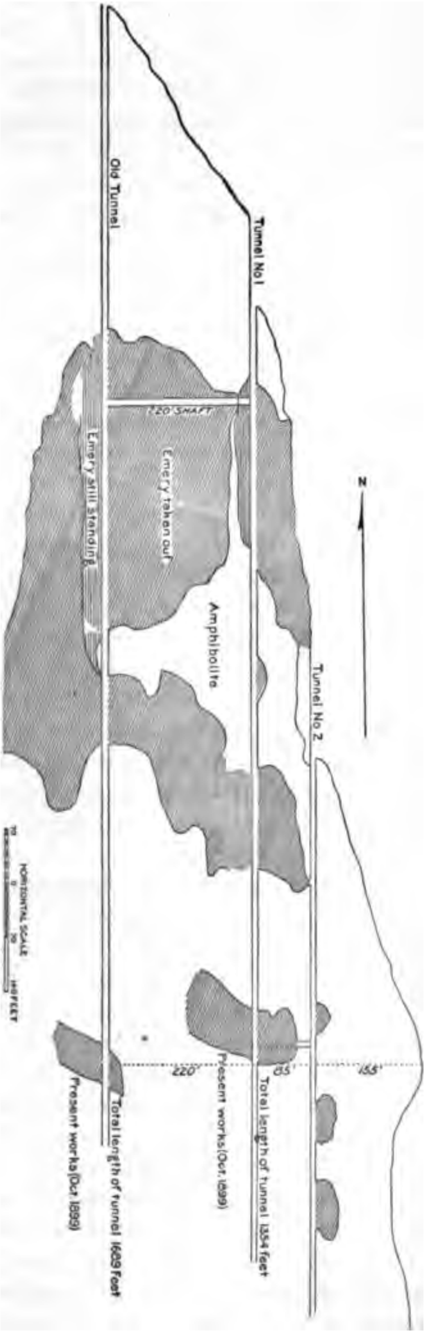

FIG. 14.—Cross section of the Old mine at Chester, Mass., showing the amount of emery taken out to April, 1899.

The last opening on the vein where there has been any work is at the Snow mine, over a mile north of the Sackett mine. A small open cut was made that exposed the vein, 3 feet in width. Between these two mines and also from the Snow mine north to the river the vein can be followed almost continuously.

While the vein can be followed nearly the whole distance, the emery does not occur throughout its entire length, for it is often in a series of pockets that are frequently connected with each other along the strike by a thin streak of chlorite and have a general dip in the vein of about N. 30°. In the direction of the dip, however, the emery is more or less continuous. The width of the vein varies from a few feet to 10 or 12, with an average width for the emery of about 6 feet. This is the most extensive deposit of emery known in this country.

Emery has also been discovered in the vicinity of Huntington, Mass., but no development work has as yet been done.

NEW YORK.

The emery deposits of this State occur associated with the norite rocks in Westchester County that have been described on page 26. Deposits of magnetite and emery have been found at a number of places 3 to 4 miles southeast of Peekskill. These deposits vary considerably in character, some being a nearly pure magnetite, others containing magnetite and spinel, and still others magnetite, spinel, and corundum. Those within a mile north and northeast of Crugers Station have been worked for iron ore, while those worked for emery are in the southeastern part of Cortland Township. The principal openings have been made on a ridge running north from Colabaugh Pond and it is here that the ore has been mined. While the iron ore and emery appear to be very rich it was found upon examination that there was more or less of a dark-green mineral mixed with magnetite, and this mineral was shown by Williams[1] to be the pleonaste variety of spinel. There is also considerable spinel in the emery, and even when this is quite abundant it can not be distinguished in the hand specimens from that in which there is almost none of this mineral.

At the emery deposits in the southeastern part of Cortland Township the percentage of corundum varies considerably at different openings, and it is sometimes observed in small blue, white, and colorless crystals. Associated with most of the corundum there is spinel, and considerable of the ore that has been mined for emery has contained little or no corundum and has been made up of magnetite and spinel. An ore of this sort would have most of the requisite properties of a true emery except the high degree of hardness due to the corundum; and when made up into a wheel it would not have the cutting efficiency of a true emery wheel. The spinel, which is 8 in hardness (corundum being 9), would play the same part in this ore as corundum in the true emery, and while not so hard as corundum it has the cutting qualities which would give the ore considerable value as an abrasive. For many purposes wheels made from this could be used fully as well as emery or corundum wheels and for some purposes they might be used to better advantage. The spinel would not interfere at all in the manufacture of a vitrified wheel

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[1] Am. Jour. Sci., 3d series, Vol. XXXIII, 1882, p. 194.

Some of the ore that has been mined here carries a very high percentage of garnet.

The analyses that have been made of this ore all show a high percentage of alumina, which was to be expected, as the spinel is an alumina mineral, $(MgFe)O.Al_2O_3$, containing about 50 per cent of this oxide. An error is very often made in judging the percentage of corundum in an ore by calculating as corundum the total percentage of alumina obtained in a chemical analysis, which would represent, however, the alumina contained in all the aluminous mineral components of the ore.

Some of the ore at these mines is undoubtedly a true emery, but a considerable portion of it is a mixture of spinel and magnetite, which, while not a true emery, will make a useful abrasive. This whole ore body might be called a spinel-emery.

From what has been said regarding the occurrence of the emery in these Peekskill deposits, their pockety nature is what would be naturally expected and this has been characteristic of all the mining that has been done in this district.

The Jackson Mills Company, of Easton, Pa., is now the largest miner in this section. It has leased the emery deposits on the land of Isaac McCoy, 3 miles southeast of Peekskill. Its principal work is on the summit of a hill about one-half mile south of McCoy's house and consists of an open cut 40 to 50 feet deep, 40 feet long, and 12 to 20 feet wide. The emery ore is from 4 to 6 feet wide, but is broken up by bands of serpentine and chloritic rocks. In some of the ore the corundum is very distinct, occurring in elongated bluish white crystals up to 5 mm. long. This ore is very free from garnet.

Another deposit of emery has been encountered 50 feet below the summit, and still another 25 feet farther down. No mining has been done at either of these localities.

The ore is hauled by teams to Peekskill, where it is shipped by rail to Easton, Pa.

On a hill 1 mile east of the McCoy mine H. M. Quinn, of Philadelphia, Pa., has mined on the land of John H. Buckby. Pockets of emery were encountered on the summit of the hill and at a number of points on its western slope, but they soon pinched out. About 50 feet below the summit a face of rock 15 to 20 feet high and 40 feet across has been exposed. The only emery seen here is the remnant of a pocket.

As far as could be learned the emery deposits of the Tanite Company of Stroudsburg, Pa., are also leased. They are on the lands of Henry Heady, Oscar Dalton, and David Chase, and are for the most part similar to the deposits just mentioned. The ore on the land of Henry Heady is composed largely of garnet, and a considerable portion of it has been shipped by the Tanite Company to their mill at Stroudsburg.

NORTH CAROLINA.

While corundum has been known to occur in quantity in this State for over thirty years, emery has until recently only been known from one locality, and here the quantity was not apparently sufficient to be worthy of any development. This deposit has been described by Genth[1] as occurring at the McChristian place, 7 miles south of Friendship, Guilford County.

During the past few years emery has been found in Macon County in what appears to be considerable quantity. Nothing definite can be stated regarding the rock in which it occurs, as it is greatly decomposed as far as it has been exposed by the excavations. It does have, however, very much the appearance of a decomposed basic magnesian rock. There are a number of small outcrops of this saprolitic rock about 5 miles southwest of Franklin, the county seat, and emery in varying quantity occurs at all of them.

These outcrops, as far as could be judged, are isolated and in no way connected with one another. They are lenticular in form and but a few hundred feet wide, the longer axis being sometimes two or three times this. While the general direction of the strike of these outcrops is nearly the same, they are not in even an approximate line as regards one another. For nearly 15 miles south of these and following the valley of the Little Tennessee River small isolated outcrops of peridotite are numerous. The country rock through which these have forced their way is a hornblende-gneiss.

Considerable mining was done two years ago by Dr. H. S. Lucas, of Franklin, at the Fairview mine near North Skeener Gap, about a hundred tons of ore having been taken out and cleaned. The vein has been tapped at intervals for a distance of nearly 200 feet, good emery being encountered at each opening. All the work done was near the summit of Fairview Knob.

One mile N. 25° W. of the Fairview mine, on the southwest slopes of Dobson Mountain, another opening has been made for emery in an outcrop of the same rock on the land of J. A. Waldroop. A vein of emery ore was uncovered here that was 15 feet wide. No mining has been done here, all the work being in the nature of prospecting.

Emery has been found in similar outcrops on the lands of William Mann, three-fourths of a mile south, and of James Ledford, one and one-fourth miles S. 30° E. of the Fairview mine.

Preliminary fire tests were made upon the cleaned product of this ore, which proved it to be well adapted for use in the manufacture of the vitrified wheel.

METHODS OF MINING CORUNDUM.

In considering the methods used in mining corundum, it must be borne in mind that up to the present time it has been obtained in quantity only where it has been associated with peridotite rocks. These rocks, as will be shown later, present certain difficulties which, if not overcome, will cause considerable delay and danger in mining. The emery occurring in amphibolite presents these difficulties in only a slight degree.

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[1] Bull. U. S. Geol. Survey No. 74, 1891, p. 30.

Nearly all of the peridotite formations in which the corundum deposits occur are bold outcrops on the mountain sides and hilltops, having almost perfect natural drainage. At all the localities where there has been no mining the little prospecting has been usually by means of open cuts supplemented by tunnels. While at first mining by means of cuts may seem to be the most advantageous, it is soon found to be the cause of considerable extra expense. These cuts, or any other openings made over the surface of the peridotite, offer a much greater opportunity for surface water and frost to penetrate the mass of the rock formation. These rocks are more or less seamed or cracked, usually to the depth that alteration can extend, and thus offer opportunities for the infiltration of water. As most of the alteration products of this peridotite formation are slippery hydrous magnesium minerals, such as serpentine and talc, and as these are developed in the seams and cracks of the peridotite, anything that is done to disturb them will make them very liable to slip. At the Corundum Hill mine there are large masses of peridotite that have become loosened and gradually slipped down and closed up some of the tunnels, and there is constant danger that fragments of the rock will fall into the cuts and some of the tunnels. At the Laurel Creek mine, a mass of peridotite with soil, etc., nearly a 200-foot cube, has become loosened and slipped downward, effectually closing up the tunnel and shaft of the Big vein.

In mining corundum associated with peridotite rocks it is therefore advisable not to break the surface of the formation any more than is absolutely necessary and to do no work at all along the contact by means of open cuts, but to confine the mining to a system of tunnels and shafts. This method of mining will be found the cheapest in the end. Then, again, all the tunnels and shafts should be well timbered and the mine kept as thoroughly drained as possible.

A large amount of the material that must be handled is easily worked with pick and shovel, as it consists of the crystals and fragments of corundum in the zone of chlorite and vermiculite. In those veins in which the corundum is associated with feldspar, as at Laurel Creek and Buck Creek, and those where there is considerable amphibole or enstatite, as at Corundum Hill, blasting is necessary. Most of the corundum deposits in peridotite are so located that there need be but little hoisting of the ore for some time. By drifting from a shaft at the upper end of a tunnel that has been run into the vein at the lowest level possible the ore can be removed with a minimum of hoisting and the mine will be kept dry.

If the mill is located some distance from the mine and a line of sluice boxes can be built, the more or less finely divided ore may be carried to it by means of these. In this way the ore is partially cleaned by the time it reaches the mill. This is the method employed at the Corundum Hill mine.

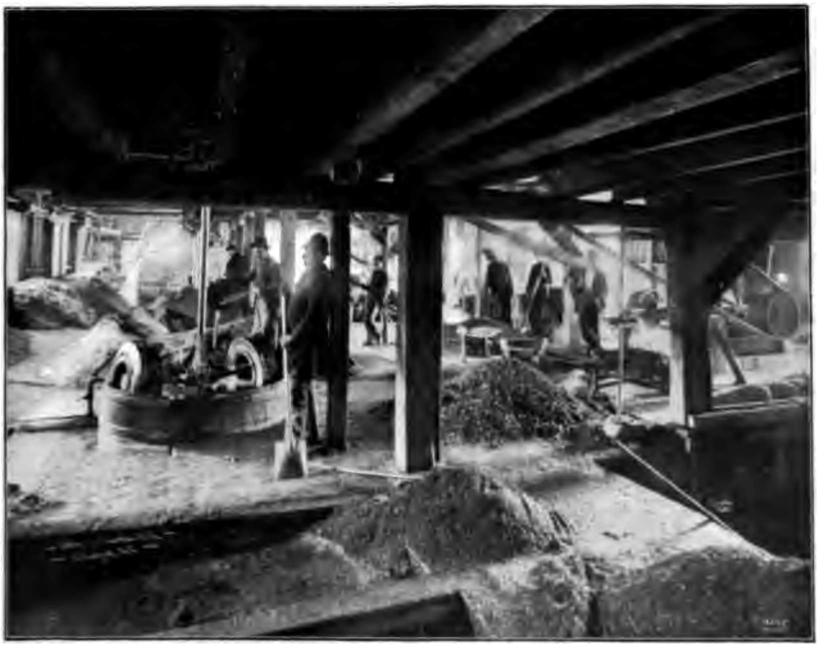
Where the corundum occurs in a gneiss, quartz-schist, or syenite, there should be no difficulty in mining by means of open cuts.

METHODS OF CLEANING CORUNDUM.

The difference between the commercial product and the ore as it comes from the mine is that the latter has been freed as far as possible of all impurities, so that the resulting product is or should be nearly pure corundum or emery. Most of the impurities are easily removed by conveying the crushed ore into boxes through which a stream of water runs, which is so regulated that the corundum readily settles to the bottom of the trough and the lighter minerals are carried off. Before this, however, the crushed ore is sieved, and all that will not pass through a No. 12 screen is recrushed and passed between rollers until it is reduced to the desired size. This washing process will remove only the impurities that are entirely separated from the particles of corundum, but there are usually some of the impurities attached to the particles or grains that have to be removed by another process. The product is passed through a machine known as the screw or scouring machine, in which there is a coarse worm similar to the screw conveyer. This grinds out almost all of the impurities, and these are separated by again subjecting them to the washing process. The final impurities are separated from the particles of corundum by means of a machine called the "muller" or "chaser" (see Pl. XIV). The principle of this is to cause each grain of corundum to rub against another and thus wear away the adhering foreign substances. The machine consists of a shallow tub, in which are two heavy wooden rollers which move around its circumference. The freshly ground corundum on being thrown into these tubs is kept constantly stirred up and then pressed down by the rollers being passed over it. In this way the scouring motion is kept up between the grains. The impurities are thus gradually worn away and are carried off by a stream of water that flows continually through the tub. The corundum in the tub is kept stirred up by men with hoes or by plow-shaped iron blades in front of the wooden rollers. It usually requires from four to eight hours, according to the nature of the impurities that are attached to the corundum grains, to obtain a clean product.

There are two methods of drying this product, by either of which it is removed from the mullers and allowed to lie overnight on inclined floors. By one method this product is conveyed by elevator belts to the second floor of the mill and dropped vertically for a distance of 20 to 30 feet down the stack of a furnace. At the bottom it strikes an

A CORUNDUM MILL AT CULLASAGEE, MACON COUNTY, N. C.



B INTERIOR VIEW OF CORUNDUM MILL AT CULLASAGEE MACON COUNTY, N. C.

inclined surface that is just above the flames of the furnace and slides down this surface into an iron box. By the other method the wet product is thrown in at the upper end of an iron cylinder, open at both ends, which revolves about a coil of steam pipes. One end of the cylinder is lower than the other, and the wet mass is alternately carried up by the revolving cylinder and dropped on the hot coil of pipes, and so gradually worked toward the lower end, where it is caught in a hopper and conveyed by elevator belts to the sizing room. Here it is automatically screened to the various sizes.

On Pl. XIV, *A* and *B*, are views of the exterior and interior of the corundum mill at Cullasagee. In the foreground of *B* are the boxes in which the ore is first washed and just beyond these are the mullers.

Only within the last few years has any attempt been made to improve the methods of concentrating and cleaning corundum. There are now a number of companies that have installed complete concentrating mills, similar to those used in concentrating gold ores, but modified to suit corundum ore. While all are using jigs for the coarser sizes of the crushed ore, some are using Frue vanners and others Bartlett or Wifley tables for the finer sizes. This method works very satisfactorily for concentrating the corundum, and if, during the crushing and rolling of the ore, the corundum is largely separated from the associated minerals, a nearly cleaned product is obtained. It is necessary, however, to subject the larger part of the concentrates to some process similar to that performed by mullers, to free the grains of corundum from other minerals attached to them.

A new machine—the Hooper pneumatic concentrator—can also probably be used to advantage in concentrating corundum ores.

Any other minerals that will be likely to remain with the corundum in the concentrates, as garnet, pyrite, etc., can undoubtedly be separated by means of the Wetherill magnetic concentrator. Unless these minerals are unattached to the particles of corundum there will be a considerable loss of corundum by this separation.

USES OF CORUNDUM.

Corundum is used for only two general purposes, as gems and as an abrasive.

The varieties of corundum that are of value as gems have been described on page 39, and the many uses that are made of the cut stones in the jewelry trade are too well known to need more than a passing notice here. One use of the corundum gem that is perhaps worthy of notice is in supplying jewels for watches. In a recent notice from the Swiss agency of precious stones for watches, Aarburg, Switzerland, it said that 75,000,000 watch jewels are required annually. With the increase of production of gem corundum in this country a great deal of the smaller fragments could and should be utilized in the manufacture of watch jewels.

Both corundum and emery are used in the manufacture of abrasive materials, and these are on the market in three forms, as wheels and blocks of various shapes and sizes, as emery paper, and as grains or powder. The last two need no further explanation, but a description of the first is of importance.

The shapes of the corundum and emery wheels and bricks or stones are extremely varied, being adapted to all kinds of grinding. The principle of these wheels is the same as that of the rotary files, and as the points of a file become dull from using, so also do the grains or points of the emery and corundum in the wheel. In making a wheel it is necessary, therefore, to make it of such a temper or grade that when these grains become dull or rounded they will fall away or will be readily removed by a truing tool, leaving fresh, sharp grains exposed. The grade of a wheel depends upon the character of the work for which it is to be used, and the bond should be such that it will wear away a little faster than the corundum or emery, and thus always leave the sharp edges ready for cutting. The greatest economy is effected when the bond does not wear away until the grains of emery or corundum have become rounded or dulled, thus permitting the wheel to do its greatest amount of work.

Before leaving the factory all wheels should be thoroughly tested to a higher strain than that to which they are to be subjected in actual use; as the wheels have to be run at a very high velocity in order to secure the greatest efficiency, there is at times but little reserve strength, and a sudden blow will often cause them to fly to pieces.

To give an idea of the number of different wheels that the larger emery-wheel companies are prepared to make, I can not do better than to mention what I saw and what was told me at the Norton Emery Wheel Company, of Worcester, Mass. The wheels are manufactured for the special work for which they are intended, and vary in shape, in bond, and in grain of corundum. The sizes of corundum that are used are Nos. 12, 14, 16, 20, 24, 30, 36, 40, 50, 54, 60, 70, 80, 90, 100, 120, 150, 160, 180, 200, and 6 grades of flour corundum. The bond has 26 degrees of hardness, represented by the letters of the alphabet, although a bond is seldom used softer than E or harder than M. There are 408 different sizes of circular wheels, so that the different grades of wheels possible are almost unlimited.

There are three types of wheels known to the trade, the vitrified, chemical, and cement, the names being derived from the process by which they are manufactured. In the manufacture of all, the corundum or emery used is in grains of uniform size, but varies with the grade of wheel that is to be made. The vitrified wheel is the most important and most generally used, although for some work one of the others is preferable, and for very large wheels the chemical is especially adapted.

VITRIFIED WHEEL.

In the manufacture of this wheel more care is necessary in the selection of the corundum, for in the vitrifaction of the bond the foreign minerals containing water are very likely to cause the wheel to burst. The corundum grains are mixed thoroughly in a paste of prepared clay and other fluxes, and the mixture is then poured into paper molds and set aside in a drying room until hard enough to be readily handled. When the molds are sufficiently dry, they are subjected to a dressing or trimming process and shaped to approximate dimensions on a potter's wheel or shaving machine, and are then further dried.

The excess of mechanical water having evaporated, they are then ready for the kilns. The kilns are cone shaped and the inside measurements vary from 12 to 20 feet in height and 10 to 18 feet in diameter. When the kiln is filled the entrance is closed and sealed and the fires are started. The temperature is allowed to rise slowly, until all the water of mechanical admixture and of crystallization in the foreign materials is driven off, when the temperature is raised to about 3,000°, or to a white heat, this heating process requiring several days. Where the foreign minerals mixed with the corundum contain water of composition that is driven off only at a very high temperature, the wheels are apt to be broken by this water coming off when the temperature of the kiln is raised to the fusing point of the clay. The clay and other fluxes fuse and form a porcelain setting for each grain or fragment of corundum, which makes a very strong bond. The kilns are allowed to cool very slowly, several days being required for this. The kiln is then opened and the wheels are brought to a lathe, called the "truing machine," where they are turned to the exact dimensions desired, the hole is bushed to the exact size, and the wheel is then trued and balanced ready for shipping.

The heat necessary for the fusion in making the vitrified wheel apparently has no effect upon the corundum beyond a partial decolorization and the expulsion of the slight percentage of water in the corundum.

CHEMICAL WHEEL.

In this process, which is also called the silicate process, silicate of soda is used as the binding material. The silicate is thoroughly mixed with the emery or corundum and some drying material and tamped into molds. It is then subjected to an "oven" heat for twenty-four hours, after which it is removed and finished according to the method described above for the vitrified wheels after they are removed from the kilns. Wheels have been made by this process that were over 2,000 pounds in weight.

CEMENT WHEEL.

In the cement wheel, shellac, rubber, linseed oil, and other substances are used as the binding material. This makes a soft wheel that is well adapted for roll and surface grinding when made with shellac, and for saw gummers and thin wheels when made with oils.

Although an examination of a corundum property may show the existence of considerable quantity of the mineral, no mining should be undertaken until satisfactory tests have been made upon the corundum to prove that it has those properties that will make it of value as an abrasive.

The value of a corundum deposit as an ore for abrasive purposes depends upon that property of the mineral which enables it to retain a sharp edge, known as a cutting edge, when it is crushed to grains. All corundums do not have this property, and while many exhibit this in the first stage of the crushing, the finer fragments and grains do not. This is more apparent when the corundum has been made into a wheel, for when first used the wheel may do good work, especially if it is a coarse-grained wheel, but as it wears away, the grains of corundum become rounded, instead of breaking to a cutting edge. In estimating the value of a corundum deposit, it is therefore very essential to determine the abrasive qualities of the corundum. Neither a chemical analysis nor a superficial examination of a corundum ore will determine its cutting qualities, and this can be obtained only by making the corundum into a wheel and testing it.

In estimating the value of an ore it is also necessary to determine to what degree of purity it can be cleaned, or what percentage of the commercial product will be corundum, and also what will be the nature of the foreign minerals. A foreign mineral will always be softer than the corundum, and will to a certain extent reduce its abrasive power. Beyond this, the presence of a small amount of foreign mineral does not materially affect the value of the corundum for making a cement or chemical wheel, but is often the reason for discarding it in manufacturing a vitrified wheel, on account of the low fusibility of the foreign substance. Garnet is perhaps the most objectionable mineral in a corundum ore, it being very difficult to separate it from the corundum, because the specific gravity of the two is nearly the same. Corundum containing even a little of the garnet can not be used in the manufacture of the vitrified wheel.

OTHER USES.

An attempt has been made to use corundum as a source of aluminum, but on account of its refractoriness and the percentage of ferric oxide and silica that it often contains, and on account of the cost of the ore, this use has not been found feasible.

The late Mr. Alfred E. Hunt, of Pittsburg, Pa., made the following statement:[1]

> The real difficulty which we find in the use of corundum for this manufacture is the cost of the raw material as compared with that of native bauxites. In this item we include not only the price of the corundum as it has been offered to us, but also the expense of grinding it to an impalpable powder, which must be done before it can be used directly in the manufacture of aluminum, and the cost of preliminary chemical treatment for purification—which latter operation, however, is also required for bauxite.

Corundum has also been used as the source of the aluminum in the manufacture of aluminum-copper and aluminum-iron alloys. In the manufacture of these the corundum, without undergoing any previous treatment, was charged into an electric furnace with a mixture of carbon and copper or carbon and iron, according to whether aluminum bronze or ferro-aluminum was desired. Since 1890, however, when alumina began to be manufactured at a comparatively low price, this artificial oxide has been used in the place of the corundum.

CORUNDUM LOCALITIES IN THE UNITED STATES.

Under this head are included practically all the localities in the United States at which corundum has been found, and if they have been described under the heading "Distribution of corundum" they are simply mentioned here. Regarding the other localities, the mode of occurrence is given in most cases, and also some idea of the extent and character of the corundum.

This list is probably not complete, but it represents all those localities that I have visited and those of which an authenticated record could be obtained. It is taken up alphabetically by States.

ALABAMA.[2]

Dudleyville.—Between this town and Perry Mills, Tallapoosa County, corundum has been picked up at a number of places in the soil, but none has been found in place. Peridotite rocks have been found in the vicinity, and it is not at all improbable that the corundum was derived from these rocks.

Hanover.—Corundum has been found sparingly in Coosa County in the vicinity of this town.

CALIFORNIA.

Plumas County.—An interesting occurrence of corundum has recently been observed in the vicinity of Meadow Valley. Cutting the serpentine rocks of the eastern slope of Spanish Peak at an elevation of about 4,100 feet, and 1½ miles west-northwest of the Meadow Valley post-office, is a series of white coarse-grained dikes that are composed of 84 per cent of oligoclase and 16 per cent of corundum. The corundum is in crystals up to 2 inches in length and 1 inch in diameter, the general habit being pyramidal, and it is distributed rather irregularly through the groundmass of feldspar. This is a further illustration of the differentiation of a rock magma, supersaturated with alumina which has crystallized out as corundum. It is still uncertain whether these deposits of corundum will prove to be of commercial importance.[1]

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[1] Trans. Am. Ins. Min. Eng., Vol. XXVIII, 1898, p. 875.

[2] Geol. Survey Alabama, Report, 1875, p. 85.

COLORADO.

Chaffee County.—Corundum crystals have been found at the Calumet iron mines in the mica-schists at their contact with intrusive dikes of diorite. R. C. Hills, geologist to the Colorado Fuel and Iron Company, writes that the ore occurs in a band of rock 6 inches to 2 feet thick that has been followed for a distance of 500 feet, and that it averages 40 per cent of corundum.

CONNECTICUT.

Litchfield.—Corundum was found here associated with talc and pyrite in a mass of blue cyanite. Only surface specimens were found.

Norwich.—In the vicinity of this place corundum was found sparingly with sillimanite.

DELAWARE.

Corundum has been found in this State in the serpentine rocks near the Pennsylvania border. The only locality definitely known is near Chandlers Hollow, in Newcastle County, about 2½ miles south of Concord, Delaware County, Pa. It has been found only in small quantity.

GEORGIA.

Acworth.—Seven miles southwest of Acworth, Cobb County, there is a large peridotite formation which is entirely within Paulding County. From a pit sunk within this formation about 1,000 pounds of corundum were taken out. It is of poor quality, but makes handsome mineral specimens.

Bell Creek mine.—This mine is 4 miles north of Hiwassee, Towns County, and the corundum, mostly of a pink color, occurs in a peridotite. The work done consists of a pit 12 feet square by 12 feet deep. Only a small quantity of corundum was found.

Centralhatchee.—At this place, which is in Heard County, grayish, white, and blue corundum has been found in a matrix of hornblende, which is associated with basic magnesian rocks.

Douglas County.—Blue corundum in a pale greenish cyanite.

Foster mine.—The corundum occurs in quartz-schist. (See p. 60.)

Gainesville.—Beautiful specimens of red corundum have been found in the peridotite formation 1 mile east of Gainesville, Hall County.

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[1] A. C. Lawson: Am. Geologist, Vol. XXVII, 1901, p. 132; J. A. Edman, letters from.

Habersham County.—Corundum has been found as surface specimens at a number of localities in this county, and at one place in the peridotite formation. There have been no developments and there are no indications of any quantity.

Hamilton mine.—The corundum occurs in a peridotite formation about 5 miles north of Young Harris, Towns County. No large quantity has been found.

Hog Creek mine.—This mine is 2 miles a little south of west of Hiwassee, Towns County, but it lacks development. The corundum is associated with peridotite, and is pink, blue, and white.

Laurel Creek mine.—In peridotite. (See p. 63.)

Monroe.—Four and a half miles from Monroe, Walton County, on the farm of George W. Breedlove, black corundum has been found associated with peridotite rocks. Some little prospecting done here has been within the formation and some near the contact.

Pine Mountain, Rabun County.—In peridotite. (See p. 63.)

Porter Springs.—One mile southeast of this place (in Lumpkin County) corundum has been found in an amphibolite, but there is no quantity.

Powder Springs.—There is a considerable outcrop of peridotite in Cobb County, in the vicinity of Powder Springs, which offers a promising place for prospecting. A small vein has been opened on the W. B. Turner farm.

Rabun Gap.—Several pounds of corundum have been obtained from the Beavett mine; it occurs in a peridotite rock.

Teltonville.—One mile north of this town, in Forsyth County, surface specimens of corundum were found which evidently originated in the quartz-schists of this region.

Stone mine.—This mine, which is in the same general formation as the Track Rock mine (see p. 65), is in Rabun County. Only a little development has been undertaken and the prospect that the deposit may be valuable is not very favorable.

Thomaston.—Seven to 8 miles southwest of Thomaston, Upson County, considerable corundum has been found on the surface at the old Kelly farm. Some of the specimens of the corundum in the matrix indicate that it was derived from a mica-schist.

Track Rock mine.—In peridotite. (See p. 65.)

West Point.—A short distance northeast of this town (in Troup County) corundum has been found sparingly in a narrow strip of peridotite. Apparently no large quantity.

MARYLAND.

Corundum has been reported to occur in the vicinity of Whitehall, but no definite information can be obtained that any has been found here beyond a stray surface specimen.

MASSACHUSETTS.

Chester.—Emery in amphibolite. (See p. 67.)

Huntington.—Emery in amphibolite. (See p. 70.)

Pelham.—Corundum in saxonite. (See p. 19.)

MONTANA.

American Bar.—The lowest bar on the Missouri River on which sapphires have been found. (See p. 47.)

Cottonwood Creek.—In the gravels of this creek greenish-colored sapphires have been found. (See p. 51.)

Dana Bar.—A bar in the Missouri River, in the gravels of which sapphires have been found. (See p. 47.)

Eldorado Bar.—Sapphires in the gravel. (See p. 47.)

Emerald Bar.—The highest bar on the Missouri River in which sapphires have been found. (See p. 49.)

French Bar.—Sapphires have been found in a small dike of andesite. (See p. 47.)

Gallatin County.—Corundum in syenite. (See p. 66.)

Magpie Gulch.—Pale-greenish sapphires have been found in the gravel. (See p. 47.)

Metropolitan Bar.—Sapphires occur in the gravels. (See p. 49.)

Missouri River bars.—In the various bars along the Missouri River, 18 miles east and northeast of Helena, sapphires have been found in the gravel. (See p. 47.)

Rock Creek.—All colors of sapphires are found in the gravel of this creek. (See p. 50.)

Ruby Bar.—Sapphires occur in an andesite dike. (See p. 47.)

Spokane Bar.—A bar of the Missouri River where the most mining has been done for sapphires that occur in the gravels. (See p. 48.)

Yogo Gulch.—Blue sapphires occur in a dike of minette. (See p. 52.)

NEVADA.

Silver Peak.—Corundum has been reported from near this place.

NEW JERSEY.

Franklin Furnace.—A small pocket of corundum has been found here associated with dolomitic limestone.

Newton.—Blue and white corundum occurs in a whitish feldspar near the contact of the granitic rock and white limestone.

Vernon.—Small pockets of corundum in limestone, but not in great quantities. (See p. 36.)

NEW YORK.

Amity.—Blue and white corundum has been found in the limestone near Amity and Warwick, Orange County. Does not occur in large uantity.

Peekskill.—A short distance east of Peekskill emery is found in basic magnesian rocks in some quantity. (See p. 70.)

NORTH CAROLINA.

Acme mine.—This mine is located about three-quarters of a mile west of Statesville, Iredell County. The corundum occurs in crystals in an amphibolite.

Addie.—Crystals of corundum have been found sparingly associated with the peridotite rocks in the vicinity of Addie, Jackson County.

Bad Creek mine.—Corundum associated with peridotite. (See p. 62.)

Bakersville.—Corundum crystals have been found sparingly in the gneiss at William Bowmans, three-fourths of a mile west of Bakersville, Mitchell County.

Behr mine.—This mine is near Elf post-office, on Shooting Creek, Clay County. Pink and white corundum have been found associated with peridotite rocks.

Belts bridge.—Crystals of black corundum occur in an amphibolite 8 miles northwest of Statesville, Iredell County, on the Hunter farm.

Betts Gap.—Corundum in splendid grayish-white crystals that are translucent are found in the gneiss to the south of the gap in Jackson County. Garnet also occurs in the gneiss.

Blue Ridge properties.—Corundum occurs in gneiss. (See p. 59.)

Brockton mine.—Corundum occurs in the peridotite. (See p. 61.)

Buck Creek mine.—Also known as the Cullakeenee. Is in a peridotite formation. (See p. 58.)

Burnt Rock mine.—In a peridotite formation. (See p. 61.)

Caler Fork.—Ruby mine, the crystals being found in the gravels of the creek. (See p. 40.)

Caney Fork.—Two miles above the mouth of this creek, in Jackson County, corundum is found in the chlorite-schist in considerable quantity. At many points along this creek and its tributaries corundum has been found in the chlorite-schists and in gneiss near these schists, as at the mouth of and also 2 miles up Chastains Creek and on Shoal Creek Mountains on the West Fork.

Carpenters Knob.—Along the ridge leading northwest from Carpenters Knob, near the border of Burke, Cleveland, and Catawba counties, corundum in grayish-blue tapering crystals is found associated with garnetiferous gneisses and schists.

Carter mine.—Corundum occurs in a peridotite formation associated with spinel. Considerable work was done here ten years ago, but since then the mine has been idle. This locality offers a somewhat promising prospect.

Celos Ridge.—Corundum crystals 2 to 3 inches long have been found sparingly in the decomposed gneiss on this ridge 8 miles southeast of Burnsville, Yancey County.

Chastains Creek.—See above, under Caney Fork.

Chunky Gal Mountains.—Corundum has been found in the bands of quartz-schists and gneiss of which the Chunky Gal Mountains are composed. Garnet is associated with the corundum, which forms a very small percentage of the rock. This occurrence is described on page 34.

Collins mine.—Pink corundum in cyanite occurs at this mine near Statesville, Iredell County.

Corundum Hill mine.—The corundum at this mine occurs in a peridotite. (See p. 55.)

Cowee Valley.—Ruby and red corundum are found in the alluvial deposits of this valley, many of which are transparent. (See description of ruby mine, pp. 40–44.)

Coweeta.—Pink corundum is found in a greenish cyanite at this place, in Macon County.

Cullakeenee mine.—Same as the Buck Creek mine.

Cullasagee mine.—This is the same as the Corundum Hill mine.

Democrat.—Corundum has been found, sparingly associated with the peridotite rocks, a little to the south of this place, in Buncombe County.

Elf.—Beautiful specimens of pink corundum are found in the green amphibolite. Occasionally there are blue pieces in this rock.

Egypt mine.—This mine is located in Yancey County, 10 miles west of Burnsville, and the corundum is in a peridotite. It is in crystalline masses and distinct crystals of a white color, often mottled with blue. This occurrence is interesting as being the only one where corundum has been found surrounded directly by dunite.

Ellijay Creek.—Corundum has been found at many points in the valley of this creek, associated with peridotite rocks. The more important of these are the Mincey, Haskett, and Higdon mines.

Fairview mine.—At this mine emery occurs in basic magnesian rocks. (See p. 72.)

Fishhawk Mountain.—At an elevation of 4,000 feet on the western slope of this mountain, on Hickory Knoll Creek, in Macon County, corundum has been found sparingly in a small outcrop of dunite.

Foster mine.—Near the summit of Chunky Gal Mountains, near the headwaters of the northern fork of Shooting Creek, in Clay County, corundum occurs in peridotite. (See p. 60.)

Gaston County.—Blue corundum, associated with mica and quartz, has been found at Chubbs, Chrowders, and Kings mountains in this county. Emery also has been found at Chrowders Mountain.

Glenville.—Four miles north of this town, in Macon County, corundum occurs in chlorite-schist similar to that on Caney Fork.

Gray property.—Corundum in peridotite. (See p. 58.)

Grimshaw Gem mine.—Sapphires of various colors have been found at this mine in peridotite. It is near Montvale post-office, Jackson County. (See p. 45.)

Hampton mine.—Same as Mine Fork.

Haskett mine.—This is given under Ellijay Creek.

Herbert mine.—This mine is on Little Buck Creek, Clay County, and is in a long, narrow arm of peridotite extending out from the main mass of the Buck Creek peridotite formation. Some prospecting has been done here, and although corundum has been found, the main mass of it occurs in connection with the main mass of peridotite.

Higdon mine.—This mine was worked for a short time, and there is connected with it a mill for washing and cleaning the ore. (See Ellijay Creek, above.)

Isbel mine.—Corundum occurs sparingly in what may be a decomposed amphibolite. One of the largest washing and cleaning mills in the State is at this mine.

Kings Mountain.—See Gaston County.

Marshall.—Corundum has been found in large gray crystals half mile north of the mouth of Big Ivy River and 3 miles above Marshall, Madison County, on the surface of a large amphibolite outcrop. It is on the property of G. C. Haynie, of Marshall. It has also been found on the property of Hon. J. C. Pritchard near the same town.

McChristians place.—Emery of reddish-brown and grayish colors has been found at this place, which is 7 miles north of Friendship, Guilford County. The property lacks development. Surface specimens of corundum have also been found here.

Mincey mine.—The corundum at this mine is found in peridotite. (See p. 58.)

Mine Fork.—Emery, associated with staurolite.

Montvale.—At many of the peridotite formations in the vicinity of Montvale, Jackson County, corundum has been found. (See p. 45.)

Newfound Gap.—A little to the south of this gap, in Haywood County, red corundum has been found on the surface of a small mass of dunite.

Nona.—Corundum in distinct crystals has been found on the surface, in the vicinity of gneiss, at Nona, Macon County.

Owens Creek.—Crystals and grains of corundum have been found in bowlders of cyanite near the mouth of this creek, in Transylvania County.

Presley mine.—This mine is located 4 miles north of Canton, Haywood County. The corundum, of a blue and bluish-gray color, occurs in a pegmatitic dike.

Reed mine.—The corundum at this mine, which is 6 miles east of Franklin, Macon County, occurs in a saprolitic rock, and is in small prismatic crystals of a bluish color, some of which are nearly transparent.

Retreat.—Near Retreat post-office, in Haywood County, corundum has been found in limited quantity in small pegmatitic dikes in the gneiss.

Sapphire.—The mines in the vicinity of this town are described on page 61.

Sapphire mine.—The corundum occurs in peridotite. (See p. 61.)

Scaly Mountain.—The corundum occurs in quartz-schist. (See p. 60.)

Sheffield mine.—The corundum at this mine is in amphibole-schist. (See p. 58.)

Skeener Gap.—Emery is found here in a basic magnesian rock. (See p. 72.)

Shoups Ford.—At this place, in Burke County, corundum has been found associated with fibrolite.

Socrates mine.—One of the mines in the vicinity of Sapphire. Corundum occurs in peridotite. (See p. 62.)

Swannanoa Gap.—Float corundum has been found near an outcrop of peridotite.

Thumping Creek.—Corundum has been found in rough nodules and flat crystals in gneiss on the property of Curtis Ledford and C. C. Patterson, on this creek, Macon County.

Turkey Knob.—On the summit of this mountain, near the Macon-Jackson county line, corundum has been found sparingly in gneiss.

Waldroop mine.—Emery has been found in a basic magnesian rock. (See p. 72.)

Watagua mine.—Same as the Reed mine.

West Mills.—Red and ruby corundum have been found in the old gravel beds of the streams on the West farm, near West Mills, Macon County.

Whitewater mine.—The corundum is in peridotite. (See p. 63.)

Winston Salem.—Near this place, in Forsyth County, emery has been found similar to that at the McChristian place.

Yellow Mountain.—The gneisses of this section carry a small percentage of corundum. (See p. 60.)

PENNSYLVANIA.

Blackhorse.—Slender grayish crystals of corundum have been found at this place, which is near Media, Delaware County. This has been found inclosed by feldspar.

Fremont.—Near this place, in West Nottingham Township, Chester County, corundum crystals have been found, surrounded by feldspar.

Mineral Hill.—Corundum crystals have been found at this place, which is near Media, in Middletown Township, Delaware County, which were surrounded by feldspar similar to that at Blackhorse.

Newlin.—See under Unionville.

Shimerville.—At this place, in Lehigh County, corundum crystals up to 8 inches in length and 4½ inches in diameter have been found loose in the soil.

Unionville.—In a large mass of serpentine rocks, 1 mile northeast 'this village, corundum has been found. (See p. 66.)

Villagegreen.—Large crystals of corundum of a brownish color are found near this village, in Aston Township, Delaware County.

West Chester—Corundum has been found in a serpentine of this township.

SOUTH CAROLINA.

Anderson County.—Corundum has been reported from this county, but none has been found in place.

Energy.—See York County.

Gaffney.—Corundum, usually of a gray color and in irregular masses up to 3 or 4 inches in diameter, has been found about 8 miles northwest of Gaffney, on the Island Ford road, near Maud post-office, on the Turner Phillips farm. It has not been found in situ, but in the gravels of a small stream and as loose fragments in the fields on the adjoining slopes. The fragments and what few crystals have been found are generally free from gangue, but some have been found with mica scales attached to them. It is not at all improbable that this corundum was derived from a mica-schist.

Laurens.—About 1¼ miles northeast of this town, in Laurens County, corundum has been found rather abundantly scattered over the surface. This surface corundum has been found for a number of miles to the southwest of this town. Although no corundum has been found in place, it was probably derived from a mica-schist, for the country rock in this section is largely a schist, and corundum crystals were found with portions of the mica-schist attached to them. The crystals are all rough, and vary from small ones to some that were over 3 inches long and 1 inch in diameter.

Oconee County.—Corundum has been found on the surface in this county, but none has been found in place.

York County.—In the northern part of this county, at Energy, near the North Carolina line, a black corundum has been found quite abundantly. (See p. 66.)

UTAH.

It is reported that a large deposit of corundum was found in this State during the past year, but no accurate information has been thus far obtained regarding location or quantity.

VIRGINIA.

Louisa County.—Deep blue crystals of corundum have been found in the soil in this county, but the exact locality is not known.

Stuart.—Corundum has been found in a mica-schist near this place on Bull Mountain. (See p. 35.) No development of the occurrence has been made to determine the extent of the deposit or the percentage of corundum.

ALASKA.[1]

Copper River.—Asteriated corundum of gray and pink colors is said to occur in a locality on Copper River, Alaska.

CORUNDUM LOCALITIES IN FOREIGN COUNTRIES.

With the exception of the emery deposits of Turkey and the Grecian Archipelago there were no localities outside of the United States where corundum had been mined for abrasive purposes until during the last year or two, when work was begun at the India deposits. As preparations are being made to work both these and the Canadian deposits on a large scale, it has seemed to me that a short description of them would be of interest and of value. I have also added a short description of the emery deposits of Turkey and the Grecian Archipelago.

CANADA.

The Canadian corundum localities that are attracting considerable attention at the present time are in the Province of Ontario, and have been recently described by Prof. W. G. Miller,[2] of the Kingston School of Mines. The corundum occurs as a primary constituent of a rock that is classified as a syenite and has been traced for over 50 miles across Renfrew, Hastings, and Haliburton counties, with smaller belts of the same rock in Peterborough, Lanark, and Frontenac counties to the south, making a total distance of nearly 100 miles in which the corundum-bearing rock has been found.

The rock varies from a normal syenite to a nepheline-syenite and a mica-syenite. Corundum has been found in all three of these varieties, but is more abundant in the normal syenite, and this rock has been named corundum-syenite. These rocks, which occur as dikes cutting through the gneisses, are sometimes in large masses that appear to grade into a granite. The width of the dikes varies greatly, but is usually several feet; a few have been observed that were only a few inches wide. These dikes are sometimes thickly studded with corundum crystals. Assays made of this rock from various parts of the dikes indicate that it will average about 12 per cent of corundum. If the corundum can be mined economically, and if tests of the commercial corundum obtained from the ore show that it has the abrasive qualities essential to make it of use in the manufacture of vitrified wheels, these deposits should become of considerable importance.

The Canada Corundum Company, Limited, has been organized and has begun mining operations on the corundum deposits in the extreme northwestern part of Raglan Township, Renfrew County, Ontario, about 7 miles southwest of Combermere. The corundum here occurs in the normal syenite. A corundum mill has been erected that will have a capacity of 5 tons of cleaned corundum a day.

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[1] Twentieth Ann. Rept. U. S. Geol. Survey, Part VI, 1899, p. 570.

[2] Report Bureau of Mines, Toronto, Can., Vol. VIII, Part II, 1899, pp. 205-240.

This company also owns corundum deposits on the York River in Carlow and Dungannon townships, Hastings County. At these localities the corundum occurs in a nepheline-syenite, and while it is apparently of superior quality to that found in Raglan Township, the percentage of corundum is not as high. No mining is being done by the company at these York River localities.

The manager of the company is Mr. B. A. C. Craig, of Toronto, Canada.

Miller[1] has described specimens of corundum from Methuen Township, Peterborough County, that are entirely inclosed by mica. He says: "The corundum is often not observed in the mica until the latter is broken open, when it is found forming the center or core of the mass. The rounded surfaces of the corundum and other characteristics leads to the belief that the masses of light-colored mica are secondary products after corundum." This very closely resembles specimens of corundum surrounded by muscovite mica that have been found at the Presley mine in Haywood County, N. C. (see p. 85), in which the muscovite is undoubtedly a secondary product after the corundum.

In the township of South Sherbrooke, Lanark County,[2] corundum has been found in a rock that is made up of a basic plagioclase feldspar and green hornblende, and has been called anorthosite by Miller. It is more basic in character than the typical varieties of this rock that have been described from other parts of Canada. The width of the belt of rock is nearly three-quarters of a mile and the corundum is found throughout the whole distance. It occurs in crystals of an almost uniform light-gray to white color that are usually about half an inch in diameter, the largest ones being one and a quarter inches long.

INDIA.

The corundum deposits of India have been described by T. H. Holland.[3] He gives the Pararapatti area in the Salem district of the province of Upper Burma as one of the most promising for the mining of corundum for abrásive purposes. He describes the corundum as occuring in a matrix of deep flesh-colored feldspar which is in bands or lenticular masses, and has associated with it often a considerable proportion of sillimanite, rutile, opaque black and green spinel, and biotite. These masses, where they have been actually seen in the rock, are sometimes as much as 15 feet long and 8 feet in diameter. The feldspar rock is composed essentially of anorthite and hornblende, and in parts has a gneissoid structure, and these portions carry the corundum. The corundum varies from a deep purplish brown to a dark greenish gray, and is in irregular nodules varying from a quarter of an inch to an inch in diameter and in elongated barrel-shaped crystals sometimes an inch long.

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[1] Report Bureau of Mines, Toronto, Ontario, Vol. VIII, Part II, 1899, p. 210.

[2] Loc cit., p. 25.

[3] Geology of India, Part III, Economic Geology, and Report Bureau of Mines, Vol. VIII, Part II, 1899, p. 230.

There are two and perhaps more of these corundum-bearing bands that are parallel to each other, making the total length of corundum-bearing rock that is known over 24 miles. The percentage of corundum in the rock is very low, experiments that have been made on samples taken at different points on the band showing the presence of only 3.5 per cent.

Most of the outcrops of the bands of corundum rock have been found in connection with gneiss, and lie in lines that are roughly parallel to the strike of the gneiss. Some of them are, however, in close proximity to a nepheline-syenite.

Specimens of corundum sent by Dr. T. L. Walker from a district about 250 miles north of Calcutta and labeled Pipra, South Rewah, India, are apparently similar to those described by Holland. The corundum is very fine grained in appearance and in nodules up to 2 or more inches long by 1 or more inches broad, with a pinkish to purplish-brown color. These nodules are partially or completely surrounded by a greenish mica, whose folia are small and rather brittle, and which has been referred by Mallet[1] to the euphyllite variety. In the mica there are small rough crystals of tourmaline. Just what the occurrence of this corundum is I do not know, but from the general appearance of the specimens it should make an ore from which the corundum could be readily separated and a very clean product obtained. If the corundum in the rock was 10 to 15 per cent of the amount required to be removed in mining, this should make a very important and profitable corundum deposit. A limited amount of this corundum is now being imported by the Norton Emery Wheel Company, of Worcester, Mass., and is used in the manufacture of their India oilstones.

In other specimens labeled Salbanni, 4 miles east southeast of Barampur, Manbhoorn district, India, there are blue crystals of corundum with a rough hexagonal prism embedded in a mass of interlocking bladed crystals of cyanite.

It is very probable that nearly all of the corundum deposits that are known in India are secondary minerals and the result of metamorphism. Professor Judd, in his paper on the Rubies of Burma and associated Minerals,[2] says that all the corundum-bearing rocks in the districts of Southern Asia appear to be gneisses that sometimes pass into schists and frequently contain masses of limestone and dolomite.

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[1] Min. India, 1887, p. 130, and Dana's Min., 6th edition, 1892, p. 624.

[2] Trans. Royal Soc., London, 1896, p. 191.

TURKEY.

The Turkish emery is obtained from the province or vilayet of Aidin, in Asia Minor, which embraces nearly the entire basins of the rivers Sarabat and Mender. Smyrna is the principal town of the province, and is the center of trade for all the surrounding district and islands. The deposits that are now being worked are on the Gumush Dagh Mountain and on the slopes of Ak Sivri,[1] which is a mountain about 125 miles to the south. The former of these deposits is about 12 miles east of the ruins of Ephesus, and just north of the river Mender; the latter is in what J. Lawrence Smith[2] describes as the Kulah district, and it is much more inaccessible than the former one. Emery has also been found in small quantities near Adula, a town about 12 or 15 miles east of Kulàh, and also at Manser, about 24 miles north, and at Allahinan-Bourgs, about 20 miles south of Smyrna.

The occurrence of the emery at all these localities is very similar, it being embedded in a bluish, coarse-grained to compact marble or limestone, resting upon mica-slates, schists, and gneisses. It always occurs in the limestone or marble; not even a trace has as yet been found in the other rocks. It does not occur in a well-defined vein but in pockets scattered irregularly through the rock that are sometimes up to 200 feet in length and 300 feet in width. The walls of these pockets are very irregular, as the limestone intrudes upon them, and then recedes very suddenly.

GRECIAN ARCHIPELAGO.

In a number of the islands of this archipelago, emery has been found in considerable quantity. The most important of these localities is the island of Naxos, where the emery is found in large blocks more or less mixed with the red soil, and also embedded in white marble. The deposits are located principally on the north and east sides of the island, the best ore being obtained from Vothrie, which is 9 miles from the coast. Another one of the better deposits on this island is at Apperonthos, which is 7 miles from the coast. In the southern part of the island the emery is found near Yasso. It occurs in such abundance on the island, in loose bowlders and in the soil, that there has been little need to mine it in the hard rock.

On the island of Nicaria emery has been found in quality equal to that from Naxos, but the quantity is not so great. A little was also found on the island of Samos. In all these islands the emery occurs in a limestone.

OTHER LOCALITIES.

Corundum has been found sparingly at many other localities, but thus far it has not been found in quantity enough to make the occurrences of economic importance as an abrasive.

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[1] Trans. Am. Inst. Min. Eng., Vol. XXVIII, 1898, p. 206.

[2] Am. Jour. Sci., 2d series, Vol. X, 1850, p. 357.

The occurrence of sapphire corundum in Burma, Ceylon, and Siam has been mentioned on pages 39 and 46.

Zirkel,[1] mentions the occurrence of corundum as an accessory mineral in the amphibolites of northwestern Austrian Silesia; in the chlorite-schist of Nischne-Issetsk, in the Urals; as a contact product of the diorites of Klausen, in Tyrol; in the andesite and tonalite of the Eifel; in a contact product of quartz-mica-diorite on quartz-phyllite in Val Moja, and similarly in the kersantite of Michaelstein, Harz; also in the graphite of Mühldorf, near Spitz, in Lower Austria.

Pirsson[2] has mentioned the occurrence of corundum in small blue sapphires in the fresh basalt of Unkel on the Rhine and Steinheim near Frankfort on the Main.

Morozewicz[3] has described the occurrences of corundum in Russia, the chief of which is in a rock composed essentially of anorthite and corundum, together with spinel and biotite. He claims that this is a new type of alumino-silicate rock, and calls it "kyschtymit." Other rocks in the Urals that contain corundum are made up almost exclusively of this mineral and orthoclase; some of these are coarse grained, while others are fine. The coarse ones have been called corundum-pegmatite and the finer ones corundum-syenite. These rocks occur as dikes cutting through gneiss.

It may be that when these corundum-bearing rocks of the Urals have been more specially examined as to their economic value they may be found to contain a large enough percentage of corundum to make them of importance as an ore of this mineral.

Dana[4] mentions the occurrence of corundum near Canton, China; in Bohemia, near Petschau; at Saint Gotthard, in dolomite; near Mozzo, in Piedmont, in white compact feldspar; and at Mudgee, New South Wales.

Lacroix, in a paper[5] on the metamorphic and eruptive rocks of Ariège, France, mentions the occurrence of corundum in the marbles of Mercus and Arignac. In a second paper[6] on acid inclusions in the volcanic rocks of the Auvergne, France, corundum is said to occur frequently in the granites and gneisses of this section. He has also described the occurrence of this mineral in the basic magmas (basalts, trachytes, and andesites) in Haute-Loire, France.[7]

Salomon[8] has described the occurrence of corundum in phyllites, epidote-amphibolites, and mica-schists at Mount Aviólo, in the Southern Alps. It occurs but sparingly in these rocks.

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[1] Lehrbuch der Petrographie, Leipsic, 1893, p. 461.

[2] Am. Jour. Sci., 4th series, Vol. IV, 1897, p. 422.

[3] Tschermaks Min. und Pet. Mitt., Vol. XVIII, pt. 1; and Rept. Bureau of Mines, Toronto, Vol. VIII, Part II, 1899, p. 285.

[4] Min., 6th edition, 1892, p. 212.

[5] Bull. des Serv. d. l. Carte géol. d. France, No. 11, Vol. II; and Am. Nat., Feb., 1891, pp. 138-139.

[6] Loc. cit.

[7] Bull. Soc. Min, Vol. XIII., 1890, pp. 100-106.

[8] Jour. d. d. G. G., Vol. XLII., 1890, p. 450; and Am. Nat., 1891, pp. 571, 572.

In the dune sands on the west coast of Holland, at Sheveningen near the Hague, corundum has been found by Retgers[1] to be one of its constituents.

In describing the geology of the district around Pretoria, South Africa, Molengraaf[2] states that the oldest rocks of the region are granites and crystalline schists. Above these are another series of schist formations, comprising quartzites, clay slates, corundum schists, porphyroids, and chiastolite-schists that are cut by diabase dikes. He states that the corundum porphyroid resembles a feldspar porphyry, and that the corundum occurs in large individuals in a groundmass of quartz and chlorite. From the description given, there is a possibility that there is corundum in quantity in this district.

In many parts of the western Yunnan district, China, as in the prefecture of Shunning Fu, sapphire, ruby, and emerald corundum are said to occur.[3]

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[1] Rec. des travaux chimiques des Pays-Bas, Vol. XI, 1892, p. 169; and Am. Nat., 1893, p. 382.

[2] Neues Jahrbuch, Vol. IX, 1894-95, pp. 174-291; and Am. Nat., 1895, p. 470.

[3] U. S. Consular Reports, Jan., 1900, Vol. LXII, No. 232, p. 95; reprinted from Mesny's Chinese Miscellany, published at Shanghai, China.

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PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Bulletin No. 180.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Bulletins, (4) Mineral Resources, (5) Water-supply and Irrigation Papers, (6) Topographic Atlas of United States—folios and separate sheets thereof, (7) Geologic Atlas of United States—folios thereof. A circular giving complete lists may be had on application.

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46. Nature and origin of deposits of phosphate of lime, by R. A. F. Penrose, jr., with introduction by N. S. Shaler. 1888. 143 pp. Price, 15 cents.

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111. Geology of Big Stone Gap coal field of Virginia and Kentucky, by Marius R. Campbell. 1893. 106 pp., 6 pls. Price, 15 cents.

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143. Bibliography of clays and the ceramic arts, by John C. Branner. 1896. 114 pp. Price, 15 cents.

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DEPARTMENT OF THE INTERIOR

BULLETIN

OF THE

UNITED STATES

GEOLOGICAL SURVEY

No. 181

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WASHINGTON
GOVERNMENT PRINTING OFFICE
1901

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

RESULTS

OF

PRIMARY TRIANGULATION AND PRIMARY TRAVERSE

FISCAL YEAR 1900-'01

BY

H. M. WILSON, J. H. RENSHAWE, E. M. DOUGLAS, AND R. U. GOODE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1901

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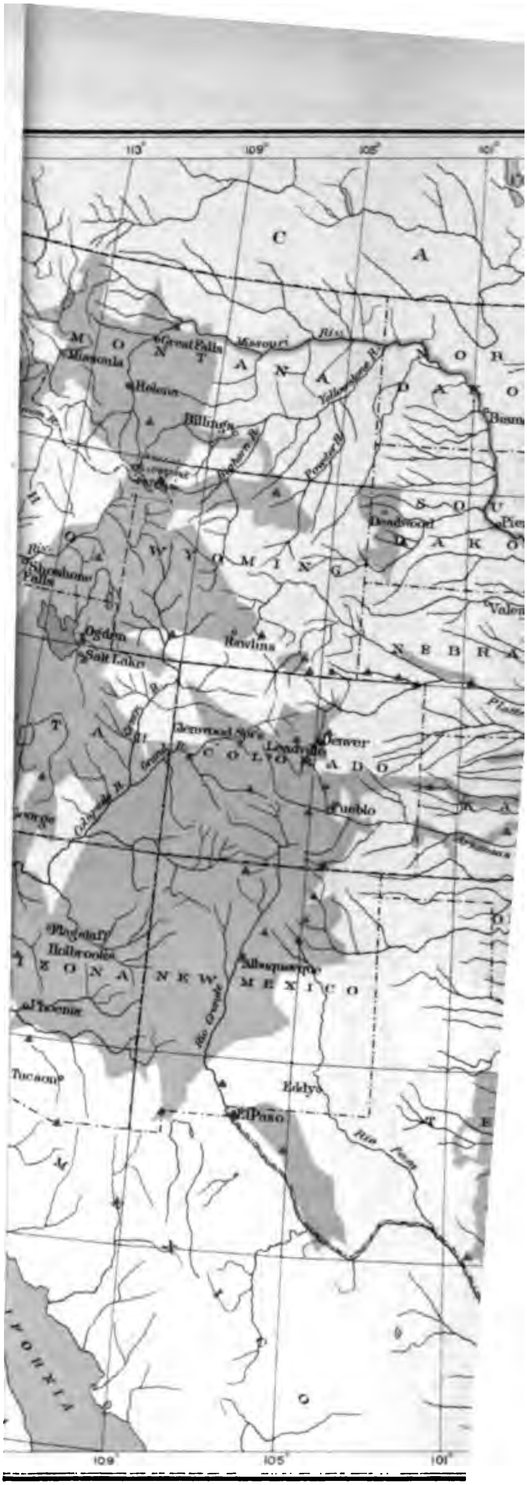
PLATE I.—Map showing condition of astronomic location and primary triangulation 17



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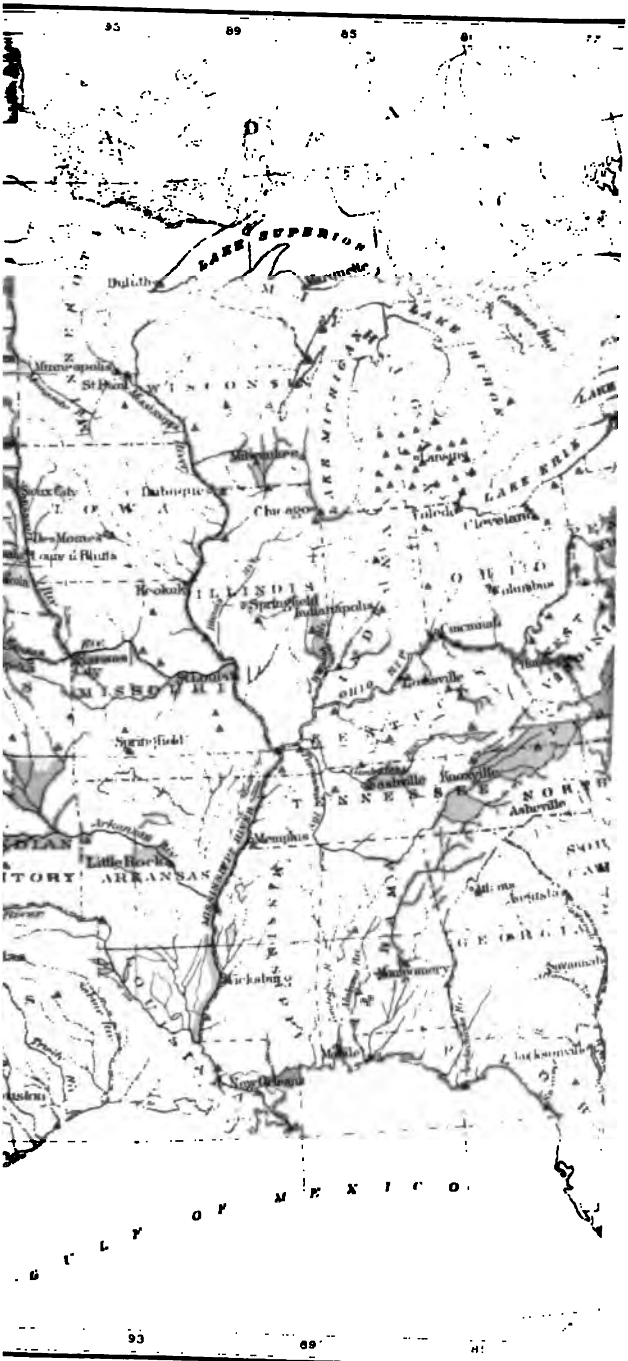

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1901.

0 400 500 800 MILES

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ILLUSTRATION.

PLATE I.—Map showing condition of astronomic location and primary triangulation 17

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., June 10, 1901.

SIR: We have the honor to transmit herewith, in form for publication, the results of the primary triangulation and primary traverse executed by the United States Geological Survey during the fiscal year 1900–'01.

The results were computed by Messrs. A. H. Thompson, George T. Hawkins, C. F. Urquhart, H. L. Baldwin, jr., W. T. Griswold, R. H. Chapman, E. L. McNair, Sledge Tatum, Oscar Jones, and D. H. Baldwin, under the direction of Mr. S. S. Gannett, who likewise compiled them for publication.

Very respectfully,
H. M. WILSON,
Geographer in charge of Atlantic section.
J. H. RENSHAWE,
Geographer in charge of Central section.
E. M. DOUGLAS,
Geographer in charge of Rocky Mountain section.
R. U. GOODE,
Geographer in charge of Pacific section.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

RESULTS OF PRIMARY TRIANGULATION AND PRIMARY TRAVERSE, FISCAL YEAR 1900-'01.

By H. M. Wilson, J. H. Renshawe, E. M. Douglas, and R. U. Goode.

SUMMARY.

Summary of published results, 1900-1901: Triangulation, primary traverse, meridian marks, and base lines.

Locality.	Triangulation stations.	Traverse stations.	Meridian marks.	Base lines.
ATLANTIC SECTION.				
Maine	11			
New York	80	73	8	
Pennsylvania	128	25	1	1
Maryland	3			
Delaware-Maryland		77		
West Virginia	15			
North Carolina		88		
South Carolina		122	5	
Ohio	19	110	3	
CENTRAL SECTION.				
Ohio		170	7	
Kentucky-Indiana		38	2	
Missouri		57		
Arkansas		22	1	
Missouri-Kansas		95	8	
Iowa		35		
ROCKY MOUNTAIN SECTION.				
South Dakota	12		1	
Montana	100			
Texas	13	29		
Utah-Wyoming	34			
PACIFIC SECTION.				
Idaho	5			
Washington	9			
California	34			
Alaska	13			
Total	476	941	36	1

RESULTS OF PRIMARY TRIANGULATION AND PRIMARY TRAVERSE, FISCAL YEAR 1900-'01.

By H. M. Wilson, J. H. Renshawe, E. M. Douglas, and R. U. Goode.

SUMMARY.

Summary of published results, 1900–1901: Triangulation, primary traverse, meridian marks, and base lines.

Locality.	Triangulation stations.	Traverse stations.	Meridian marks.	Base lines.
ATLANTIC SECTION.				
Maine	11			
New York	80	73	8	
Pennsylvania	128	25	1	1
Maryland	3			
Delaware-Maryland		77		
West Virginia	15			
North Carolina		88		
South Carolina		122	5	
Ohio	19	110	3	
CENTRAL SECTION.				
Ohio		170	7	
Kentucky-Indiana		38	2	
Missouri		57		
Arkansas		22	1	
Missouri-Kansas		95	8	
Iowa		35		
ROCKY MOUNTAIN SECTION.				
South Dakota	12		1	
Montana	100			
Texas	13	29		
Utah-Wyoming	34			
PACIFIC SECTION.				
Idaho	5			
Washington	9			
California	34			
Alaska	13			
Total	476	941	36	1

ATLANTIC SECTION OF TOPOGRAPHY.

MAINE.

Triangulation Stations.

Triangulation of 1899 was extended northeastward from Charleston and Lowell stations during July and August, 1900, by Mr. S. S. Gannett, who occupied 7 stations and located 5 points controlling 3 fifteen-minute quadrangles.

CARROLL, PENOBSCOT COUNTY.

On a high ridge in Carroll Township, 1 mile southwest of Carroll post-office, on land owned by Fred Oliver, who lives 75 yards east of station. Timber 30 feet high on north end of ridge obstructs view from northwest round by north to southeast.

Station mark: A copper bolt cemented in upper surface of embedded bowlder.

[Latitude 45° 24′ 22.50″. Longitude 68° 03′ 14.84″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Almanac	23 59 53.9	203 58 12.1	3.8837120
Passadumkeag	37 47 47.5	217 34 52.7	4.5892082
Peasley	58 49 26.7	238 33 41.2	4.5300442
Knob	75 43 22.6	255 29 35.0	4.4161767
Woodville	103 27 24.3	283 08 40.6	4.5467760
North Woodville	119 35 31.8	299 18 47.6	4.5457384
Katahdin	129 38 22.4	309 01 23.0	4.9394592

ALMANAC, PENOBSCOT COUNTY.

On a high ridge in Lakeville Township, 1½ miles south of South Springfield, on land owned by Philo Bearce. Small timber at east end.

Station mark: A granite post 30 by 8 by 8 inches, set 16 inches in ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 45° 20′ 36.07″. Longitude 68° 05′ 37.77″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Passadumkeag	41 05 34.7	220 54 22.9	4.4977135
Peasley	67 47 20.8	247 33 17.5	4.4463959
Knob	91 25 10.6	271 13 06.6	4.3455954
Woodville	115 58 03.0	295 41 01.6	4.5396474
North Woodville	131 32 42.6	311 17 40.6	4.5643863
Carroll	203 58 12.1	23 59 53.9	3.8837121

PASSADUMKEAG, PENOBSCOT COUNTY.

Situated on the east end of Passadumkeag Mountain, the highest point in the town of Grand Falls.

Station mark: Tall spruce tree blazed on four sides.

[Latitude 45° 07′ 47.04″. Longitude 68° 21′ 23.90″.].

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Peaked	14 18 22.0	194 13 47.8	4.5375904
Greenfield	50 16 23.2	230 12 13.3	4.0014896
Peasley	158 13 15.5	338 10 24.8	4.1502341
Carroll	217 34 52.7	37 47 47.5	4.5892082
Almanac	220 54 22.9	41 05 34.7	4.4977135

KNOB, PENOBSCOT COUNTY.

(Not occupied.)

A prominent timbered peak in the east-central portion of town of Lincoln.

Station mark: A tree on summit of peak.

[Latitude 45° 20′ 52.60″. Longitude 68° 22′ 35.45″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Peasley	18 18 53.7	198 16 53.6	4.0689899
Fish Hill	88 43 51.8	268 38 13.3	4.0140397
Woodville	148 12 22.3	328 07 26.0	4.2346552
Carroll	255 29 35.0	75 43 22.6	4.4161767
Almanac	271 13 06.6	91 25 10.6	4.3455954

PEASLEY, PENOBSCOT COUNTY.

On highest point of bare, grass-covered hill in the town of Burlington, east of Esculassis Pond.

Station mark: A bronze triangulation tablet cemented in solid granite, level with surface of ground.

[Latitude 45° 14′ 52.10″. Longitude 68° 25′ 24.35″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Greenfield	7 09 42.6	187 08 23.0	4.2943006
Lowell	130 08 37.8	310 06 15.9	3.7554309
Fish Hill	148 36 13.3	328 32 36.2	4.1059741
Woodville	168 11 27.1	348 08 31.0	4.4194598
North Woodville	177 11 03.0	357 10 06.6	4.5431412
Knob	198 16 53.6	18 18 53.7	4.0689899
Carroll	238 33 41.2	58 49 26.8	4.5300442
Almanac	247 33 17.5	67 47 20.8	4.4463959
Passadumkeag	338 10 24.8	158 13 15.5	4.1502341

NORTH WOODVILLE, PENOBSCOT COUNTY.

(Not occupied.)

On a cultivated ridge in northern central portion of Woodville Plantation.

Station mark: A clump of bushes in a big pile of granite bowlders.

[Latitude 45° 33′ 42.03″. Longitude 68° 26′ 43.47″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Woodville	21 44 32.7	201 42 33.2	3.9944700
Carroll	299 18 47.6	119 35 31.8	4.5457384
Almanac	311 17 40.6	131 32 42.6	4.5643863
Peasley	357 10 06.6	177 11 03.0	4.5431412

LOWELL, PENOBSCOT COUNTY.

Situated on the summit of the highest hill, in heavy timber, to the east of Cold Stream Pond in the northern part of the town of Lowell. Sight lines were cut to stations Charleston, Pine Tree, Woodville, Peasley, and Greenfield.

Station mark: A bronze triangulation tablet cemented in solid rock and marked "U. S. Geological Survey, Maine."

[Latitude 45° 16′ 50.97″. Longitude 68° 28′ 44.06″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Charleston	66 00 13.7	245 37 20.2	4.6657619
Pine Tree	82 38 15.6	262 26 20.2	4.3452270
Woodville	177 18 08.3	357 17 34.3	4.3437360
Peasley	310 06 15.9	130 08 37.8	3.7554309
Greenfield	355 17 11.2	175 18 13.2	4.3671206

WOODVILLE, PENOBSCOT COUNTY.

On a cleared ridge in southwest corner of Woodville Plantation, on land owned by Jerry Glidden, who lives on southeast side of ridge; station on east side of a big pile of rocks on bare ledge. View obstructed by timber on northeast end of ridge.

Station mark: A granite post 18 by 11 by 11 inches, set 12 inches in the ground on solid ledge; in the center of top of post is cemented a bronze triangulation tablet.

[Latitude 45° 28′ 44.96″. Longitude 68° 29′ 31.88″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Fish Hill	4 51 40.0	184 50 58.8	4.1724197
Charleston	45 16 07.4	224 53 45.6	4.7641319
Mattamiscontis	80 48 44.4	260 39 00.8	4.2547967
Katahdin	144 59 59.6	324 41 48.5	4.7597900
North Woodville	201 42 33.2	21 44 32.7	3.9944700
Carroll	283 03 40.6	103 27 24.3	4.5467760
Almanac	295 41 01.6	115 58 03.0	4.5396474
Knob	328 07 26.0	148 12 22.3	4.2346552
Passadumkeag	344 38 29.2	164 44 17.8	4.6049016
Peasley	348 08 31.0	168 11 37.1	4.4194598
Lowell	357 17 34.3	177 18 08.3	4.3437360

FISH HILL, PENOBSCOT COUNTY.

On a cleared hill one mile south of Lincoln Village in the town of Lincoln, overlooking all country, though view is limited southward to about 5 miles and eastward to about 6 miles.

Station mark: A granite post 30 by 7 by 7 inches set 28 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 45° 20′ 44.90″. Longitude 68° 30′ 29.78″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Charleston	56 54 19.7	236 32 40.6	4.6789897
Mattamiscontis	125 55 04.5	305 46 04.2	4.3087467
Katahdin	152 51 44.8	332 34 12.4	4.8425063
Woodville	184 50 58.8	4 51 40.0	4.1724197
Knob	268 38 13.3	88 43 51.8	4.0140397
Peasley	328 32 36.2	148 36 13.3	4.1059741
Passadumkeag	333 34 27.2	153 40 59.7	4.4282994

MATTAMISCONTIS, PENOBSCOT COUNTY.

(Not occupied.)

A well-known prominent mountain, 10 miles (air line) northwest of Lincoln.

Station mark: A tall pine tree on highest point.

[Latitude 45° 27′ 11.05″. Longitude 68° 43′ 08.55″.]

To station—	Azimuth.	Back azimuth.	Log distance.
	° ′ ″	° ′ ″	*Meters.*
Charleston	31 35 31.0	211 22 49.8	4.6503316
Woodville	260 39 00.8	80 48 44.4	4.2547967
Fish Hill	305 46 04.2	125 55 04.5	4.3087467

KATAHDIN, PISCATAQUIS COUNTY.

(Not occupied.)

The highest and best-known mountain in Maine.

Station mark: Sharp, rocky summit of mountain.

[Latitude 45° 54′ 08.01″. Longitude 68° 55′ 02.15″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Charleston	5 04 30.3	185 00 15.2	4.9463810
Carroll	309 01 23.0	129 38 22.4	4.9394592
Woodville	324 41 48.5	144 59 59.6	4.7597900
Fish Hill	332 34 12.4	152 51 44.8	4.8425063

NEW YORK.

Triangulation Stations.

During the season of 1900 four parties were engaged on triangulation in New York under the general supervision of Mr. S. S. Gannett. In the central portion of the State a belt of triangulation was extended by Messrs. Griswold and McNair from Virgil-Warren eastward to Utsayantha-Otsego stations of the Gardiner State survey. In the southeastern portion of the State the work of the United States Coast and Geodetic Survey was extended northward by Mr. Oscar Jones from stations Bearfort, High Point, Hamburg, and High Torne, connecting with the work of Mr. McNair at stations Andes, Bramley, and Utsayantha.

During the summer months Mr. McNair was transferred to the Adirondack region, where he executed control for six 15′ quadrangles by triangulation based upon Blue-Vanderwhacker. Twelve stations were occupied and 6 points located by intersections. During September he ran a line of primary traverse from Ogdensburg light-house (located by the United States Lake Survey) to Churubusco and Owls Head (triangulation stations of the United States Geological Survey) with several spur lines, a total distance of 142 miles, furnishing control for five 15′ quadrangles.

Mr. S. Tatum extended triangulation northward from Penn-Myer, occupying nine stations, and also occupied and located one station, Webb, from West and Morris, the total number of quadrangles controlled being four.

The net results of the season's work were the occupation of 70 triangulation stations and the running of 142 miles of primary traverse, controlling 44 quadrangles in portions of the counties of Orange, Sullivan, Ulster, Delaware, Otsego, Oneida, Madison, Chenango, Cortland, Broome, Herkimer, Essex, Hamilton, Franklin, Clinton, Lewis, and St. Lawrence. Meridian lines were established at Goshen, Delhi, Cooperstown, Utica, Hamilton, Norwich, Binghamton, and Malone.

AVERILL, CLINTON COUNTY.

On a high, cleared mountain about 3 miles southeast of Lyon Mountain station on Chateaugay Railway.

Station mark: A copper bolt set in solid rock and marked "Adirondack Survey—V. C. 33."

[Latitude 44° 41′ 34.68″. Longitude 73° 52′ 52.72″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Moose Peak	14 27 33.2	194 22 22.9	4.5938655
Lookout	45 48 07.8	225 41 01.8	4.2709061
Debar	69 52 33.0	249 38 13.6	4.4582297
Owls Head (2)	104 23 30.2	284 11 44.7	4.3573875

MARCY, ESSEX COUNTY.

A high, bare mountain, the highest in the Adirondacks, in the western part of Keene Township. There is a good trail to the summit from Adirondack Lodge, 9 miles distant, and one from the Ausable Lakes, about the same distance.

Station mark: A copper bolt in solid rock, marked "Station No. 1 N. Y. S. Adirondack Mtn. Survey."

[Latitude 44° 06′ 46.10″. Longitude 73° 55′ 26.99″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Vanderwhacker	30 08 51.4	210 01 40.7	4.4401357
Blue	35 16 19.8	234 56 26.4	4.6690929
Seward	103 23 59.8	283 12 28.2	4.3557847
McIntyre	124 11 47.0	304 09 09.0	3.7850100
Moose Peak	166 25 55.8	346 22 34.7	4.4347725

M'INTYRE, ESSEX COUNTY.

(Not occupied.)

A very high, bald mountain in the southern part of North Elba Township.

Station mark: A bolt, probably of the New York State land survey.

[Latitude 44° 08′ 37.04″. Longitude 73° 59′ 13.82″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Vanderwhacker	17 50 39.0	197 46 05.0	4.4568900
Seward	96 05 50.0	275 56 56.0	4.2336600
Ampersand	120 25 51.0	300 16 49.0	4.3012800
Moose Peak	176 37 12.0	356 36 30.0	4.3629900
Marcy	304 09 09.0	124 11 47.0	3.7850100

MOOSE PEAK, ESSEX COUNTY.

On a high, cleared mountain in the northwestern part of Essex County on the north side of Lake Placid. There is a good trail from the Lake Placid side.

Station mark: A half-inch hole drilled in bowlder.

[Latitude 44° 21′ 03.06″. Longitude 74° 00′ 15.23″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Seward	36 26 49.6	216 18 37.6	4.4210862
Ampersand	50 26 33.0	230 48 13.0	4.3110300
McKenzie	54 34 31.0	234 33 19.5	3.4435800
Morris	60 44 41.0	240 24 56.6	4.6357242
St. Regis	104 00 49.1	283 47 08.7	4.4273682
Debar	148 30 49.6	328 21 42.8	4.5178874
Lookout	171 46 17.4	351 44 22.7	4.4023504
Averill	194 22 22.9	14 27 33.2	4.5938655
Marcy	346 22 34.7	166 25 55.8	4.4347725

LOOKOUT, FRANKLIN COUNTY.

A bare rocky mountain about 2 miles east of Loon Lake. Can be reached from Loon Lake House by trail in about 1½ hours, or from Loon Lake station by road and trail in about same time.

Station mark: A bronze triangulation tablet cemented in solid rock and marked "U. S. Geological Survey, New York."

[Latitude 44° 34′ 32.80″. Longitude 74° 02′ 59.05″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
St. Regis	50 18 59.7	230 07 12.4	4.4626659
Debar	102 50 04.4	282 42 51.5	4.1444627
Owls Head (2)	154 56 52.4	334 52 13.9	4.3135926
Averill	225 41 01.8	45 48 07.8	4.2709061
Moose Peak	351 44 22.7	171 46 17.4	4.4023504
McKenzie	357 03 40.0	177 04 23.0	4.4255200

M'KENZIE, ESSEX COUNTY.

(Not occupied.)

A high cleared mountain in northwestern part of Essex County, about 3 miles northwest of Lake Placid.

Station mark: Probably a bolt of New York State land survey.

[Latitude 44° 20′ 10.91″. Longitude 74° 01′ 57.39″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Seward	34 20 28	214 13 28	4.37558
Ampersand	50 21 12	230 14 03	4.24787
St. Regis	108 49 40	288 37 11	4.39856
Lookout	177 04 23	357 03 40	4.42552
Moose Peak	234 33 19	54 34 31	3.44358
Marcy	340 43 55	160 48 28	4.42010

OWLS HEAD (2), FRANKLIN COUNTY.

On a rocky point about one-half mile northeast of Owls Head station, on Mohawk and Malone Railway. Ridge is considerably higher to north. View cut off from north to east.

Station mark: A copper bolt leaded in rock, marked "U. S. G. S."

[Latitude 44° 44′ 36.81″. Longitude 74° 09′ 35.30″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Debar	17 20 43.9	197 18 09.0	4.2121883
Averill	284 11 44.7	104 23 30.2	4.3573875
Lookout	334 52 13.9	154 56 52.4	4.3135926

HIGH TORNE, ROCKLAND COUNTY.

A station of the United States Coast and Geodetic Survey in Ramapo Township about 1 mile northeast from Ramapo station on the New York, Lake Erie and Western Railroad, on the summit of a prominent elevation known as High Torne, which falls off abruptly on the southeast end. Station is about 400 feet northeast from a large cliff. Land is owned by H. I. Pierson, of Ramapo.

Station mark: A three-fourths inch bolt cemented in solid rock.

[Latitude 41° 09′ 05.30″. Longitude 74° 09′ 47.32.″]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bald Hill	36 48 57.0	216 41 32.8	4.4214816
Bearfort	86 28 25.3	266 19 23.1	4.2845292
Sterling	152 57 22.4	332 54 23.9	4.1420525

SEWARD, FRANKLIN COUNTY.

In the southeastern part of Franklin County, on a high mountain 3 miles south of Ampersand Pond. It is covered with a dense growth of small balsam, but summit has been partly cleared. Best reached from cabin of Santa Clara Lumber Company on Ampersand Pond. Follow up Ward Brook on logging road, take second left-hand road, then keep to left to end of road, whence a blazed trail may be followed to summit.

Station mark: A copper bolt set in solid rock 2 feet below surface of ground.

[Latitude 44° 09′ 35.25″. Longitude 74° 12′ 00.22″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Blue	26 54 00.0	206 45 36.3	4.5535558
Morris	90 05 24.8	269 53 53.6	4.3433268
St. Regis	159 28 26.7	339 22 59.9	4.4704091
Ampersand	178 17 56.0	358 17 48.0	3.9201400
McKenzie	214 13 28.0	34 20 28.0	4.3755800
Moose Peak	216 18 37.6	36 26 49.6	4.4210862
McIntyre	275 56 56.0	96 05 50.0	4.2336600
Marcy	283 12 28.2	103 23 59.8	4.3557847
Vanderwhacker	344 00 06.0	164 04 25.4	4.4803631

AMPERSAND, FRANKLIN COUNTY.

(Not occupied.)

A bare rocky mountain in the southeastern corner of Franklin County, on the north side of Ampersand Pond. Can be easily reached from Ampersand Pond.

Station mark: Bolt, probably, of the New York State Land Survey.

[Latitude 44° 14′ 04.68″. Longitude 74° 12′ 11.35″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Morris	69 11 42	249 00 18	4.36771
Hayes	87 26 27	267 16 25	4.28293
St. Regis	152 24 35	332 19 16	4.33909
McKenzie	230 14 03	50 21 12	4.24787
Moose Peak	230 48 13	50 26 33	4.31103
McIntyre	300 16 49	120 25 51	4.30128
Seward	358 17 48	178 17 56	3.92014

DEBAR, FRANKLIN COUNTY.

A high cleared mountain in Duane Township, about 4 miles south of Duane post-office. Best reached from Debar Pond on northeast side of mountain. No trail.

Station mark: A bronze triangulation tablet cemented in solid rock and marked "U. S. Geological Survey, New York."

[Latitude 44° 36′ 12.71″. Longitude 74° 13′ 15.66″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
St. Regis	21 52 12.9	201 47 37.7	4.3678052
Rice	45 07 15.0	225 01 52.0	4.1566600
Azure	72 48 18.5	252 36 30.5	4.3676167
Owls Head (2)	197 18 09.0	17 20 43.9	4.2121883
Averill	249 38 13.6	69 52 33.0	4.4582297
Lookout	282 42 51.5	102 50 04.4	4.1444627
Moose Peak	328 21 42.8	148 30 49.6	4.5178874
Duane M. E. Church	151 53 58.0	331 52 12.0	3.8487800

STERLING, ORANGE COUNTY.

Near the west side of a bushy ridge in Tuxedo Township, S. 67° W. 1½ miles from the southwest extremity of Lake Mombasha, on land owned by the Sterling Park Company.

Station mark: A copper bolt 1 inch in diameter wedged in bowlder and ⅜ inch above surface, stamped "U. S. G. S." Bowlder 2 by 3 feet and 6 inches above ground.

Reference marks: Arrow cut near north end of bowlder 3 by 4 feet and 4 inches above ground; azimuth 30°, distance 8.04 feet. Arrow cut in bowlder 6 by 4 feet and 1 foot above ground; azimuth 70°, distance 13.70 feet. Arrow cut in bowlder 5 by 3 feet and 1 foot above ground; azimuth 287°, distance 5.51 feet. Signal tree; azimuth 148°, distance 29.01 feet.

[Latitude 41° 15′ 45.64″. Longitude 74° 14′ 18.21″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bearfort	43 35 48.2	223 29 43.8	4.2720153
High Point	100 28 18.1	280 11 32.0	4.5570329
Eve	106 22 40.1	286 15 41.1	4.1875280
Houston	158 03 52.5	337 59 03.7	4.4333572
Sams Point	167 43 03.4	347 38 20.8	4.6666435
High Torne	332 54 23.9	152 57 22.4	4.1420535

DUANE, M. E. CHURCH, FRANKLIN COUNTY.

(Not occupied.)

Situated in Duane Township near Duane post-office.

Station mark: Center of church spire.

[Latitude 44° 39′ 34.43″. Longitude 74° 15′ 46.59″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Azure	55 16 13	235 06 10	4.36259
Debar	331 52 12	151 53 58	3.84878

ST. REGIS, FRANKLIN COUNTY.

On a bare rocky mountain about 5 miles west of Lake Clear Junction, on Mohawk and Malone Railway. Can be reached in about three hours from Lake Clear Junction by driving to Upper St. Regis Lake, thence taking boat to head of lake, a short carry to Spectacle Pond, thence across the pond, thence a good trail to summit.

Station mark: An aluminum bolt set in solid rock and marked "N. Y. S. Land Survey V. Colvin Supt. No. 300."

[Latitude 44° 24′ 31.27″. Longitude 74° 19′ 48.32″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Morris	22 50 21.0	202 44 15.1	4.4771258
Hayes	24 02 35.0	203 57 51.0	4.3452200
Azure	137 17 13.9	317 10 02.2	4.3022069
Rice	172 37 34.0	352 36 47.0	4.0651500
Debar	201 47 37.7	21 52 12.9	4.3678052
Lookout	230 07 12.4	50 18 59.7	4.4626659
Moose Peak	283 47 08.7	104 00 49.1	4.4273682
McKenzie	288 37 11.0	108 49 40.0	4.3985600
Ampersand	332 19 16.0	152 24 35.0	4.3390900
Seward	339 22 59.9	159 28 26.7	4.4704091

KEMPSHALL, HAMILTON COUNTY.

A heavily timbered mountain in the town of Long Lake, on the east side of Long Lake, 2 miles south of Island Hotel. Sight lines are cleared through timber to Blue, West, Nigger Head, Owls Head, Morris, St. Regis, and Ampersand. Theodolite elevated 20 feet on trunk of tree.

Station mark: Center of trunk of tree 2 feet in diameter cut off 20 feet from ground. Station number, 493.

Reference mark: A copper bolt set in a bowlder 2½ feet in diameter embedded in the roots of trunk, bolt being 2 feet northwest of center of tree.

[Latitude 44° 01′ 28.43″. Longitude 74° 19′ 48.97″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Blue	18 42 04.4	198 39 06.6	4.2512882
West	58 57 16.0	238 41 35.4	4.5481265
Morris	142 16 28.2	322 10 24.0	4.2789159

RICE, FRANKLIN COUNTY.

(Not occupied.)

On a partly cleared mountain about 3 miles east of Madawaska station, on the New York and Ottawa Railway. Can go in rowboat from station to foot of mountain.

Station mark: A bronze triangulation tablet cemented in solid rock.

[Latitude 44 30′ 44.56″. Longitude 74° 20′ 55.82″]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Azure	104 50 29	284 44 03	4.09800
Debar	225 01 52	45 07 15	4.15666
St. Regis	352 36 47	172 37 34	4.06515

SAMS POINT, ULSTER COUNTY.

In Warwarsing Township, 6 miles from Ellenville, on the southern end of a rocky ridge locally known as Sams Point, and owned by Le Grand Bottsford, who lives under the bluff 400 yards south of station.

Station mark: A bronze triangulation tablet cemented in a large flat rock.

Reference marks: Arrow cut in flat rock; azimuth 1°, distance 38.43 feet. Arrow cut in flat rock; azimuth 297°, distance 51.97 feet. Arrow cut in flat rock; azimuth 190°, distance 14.22 feet.

[Latitude 41° 40′ 15.46″. Longitude 74° 21′ 25.02″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Houston	0 39 23.5	180 39 16.9	4.3051821
High Point	33 19 35.9	213 07 28.5	4.6672128
Vernon	36 58 17.9	216 51 59.9	4.3415805
Roads	56 10 16.9	235 59 37.5	4.4292886
Wolf	66 48 34.2	246 39 29.6	4.3149145
Monticello	87 17 09.0	267 04 09.7	4.4338327
Walnut	110 49 25.5	290 32 56.2	4.5648950
South Hill	142 43 36.1	322 37 17.4	4.3358465
Denman	149 31 57.0	329 24 36.5	4.4778895
Graham	158 42 30.5	338 34 47.4	4.6430438
Slide	176 10 36.6	356 09 27.3	4.5627499
Sterling	347 38 20.8	167 43 03.4	4.6666435

HOUSTON, ORANGE COUNTY.

On a cleared hill in Walkill Township, one-half mile north of Scotchtown post-office, on land owned by Robert Houston. Harry Smith lives 300 yards south of station. A good view in all directions.

Station mark: A stone post 20 by 8 by 8 inches, set flush with the surface of ground, in center of top of which is cemented a bronze triangulation tablet.

Reference marks: Large stone pile in fence corner; azimuth 185°, distance 119.85 feet. Arrow cut in north end white rock 3 by 2 feet and 1 foot above ground; azimuth 340°, distance 164.73 feet. Arrow cut in north end of rock ledge 10 by 4 feet and 1 foot above ground; azimuth 23°, distance 242.22 feet. Stone wall; azimuth 90°, distance 60 feet.

[Latitude 41° 29′ 20.99″. Longitude 74° 21′ 35.00″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Eve	12 29 31.5	192 27 20.4	4.3289821
High Point	53 37 03.5	233 25 04.0	4.4973076
Writer	73 27 08.3	253 18 36.1	4.2725795
Vernon	101 32 05.0	281 25 54.3	4.1219453
Sams Point	180 39 16.9	0 39 23.5	4.3051821
Sterling	337 59 03.7	158 03 52.5	4.4333572

SLIDE, ULSTER COUNTY.

On the highest peak in the Catskill Mountains, 5 miles south of Slide Mountain post-office, or J. W. Dutcher's house.

The nearest railroad station is Big Indian, on the Ulster and Delaware Railroad.

The top of the mountain is timbered. Theodolite set under center of a tower 25 feet high and lines of sight cut toward other stations.

Station mark: A copper bolt stamped "U. S. G. S." set in a conglomerate rock a little above surface of ground.

Reference marks: Six-inch spike driven in a balsam tree 12 inches in diameter, 2½ feet above ground; azimuth 38°, distance 27.07 feet. Arrow cut in ledge in path around north side of tower; azimuth 244°, distance 32.65 feet. Arrow cut in ledge of rock, east outlook from mountain; azimuth 289°, distance 220.65 feet.

[Latitude 41° 59′ 57.11″. Longitude 74° 23′ 10.87″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Walnut	53 42 07.4	233 26 44.2	4.5971647
Graham	108 23 15.3	288 16 41.6	4.1539653
Andes	130 32 52.6	310 18 47.4	4.5803074
Utsayantha	159 19 04.0	339 10 51.4	4.6765330
Sams Point	356 09 27.3	176 10 36.6	4.5627499
South Hill	29 03 59.8	208 58 49.8	4.3421254

BEARFORT, PASSAIC COUNTY, N. J.

A station of the United States Coast and Geodetic Survey on a high summit of Bearfort Mountain, about 2 miles southwesterly from road leading over mountain from Greenwood Lake to Vernon.

Station mark: A copper bolt three-fourths inch in diameter projecting about three-fourths inch above rock.

[Latitude 41° 08′ 26.09″. Longitude 74° 23′ 31.35″.]

To station	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hamburg	94 11 30.7	274 06 02.8	4.0664557
High Point	131 36 05.8	311 25 25.5	4.4802442
Eve	173 54 55.4	353 54 01.4	4.2549964
Sterling	223 29 43.8	43 35 48.2	4.2720153
High Torne	266 19 23.1	86 28 25.3	4.2845292
Bald Hill	350 10 07.9	170 11 44.9	4.3060559

EVE, ORANGE COUNTY.

On the western end of a partly cleared ridge in Warwick Township, 2½ miles from Hudson. Station on the Lehigh and Hudson Railroad. Land owned by James Henry, who lives 400 yards north of station at foot of mountain.

Station mark: A copper bolt stamped "U. S. G. S." set in solid rock.

Reference marks: Arrow cut in ledge on top of ridge; azimuth 30°, distance 24.25 feet. Arrow cut in ledge on top of ridge; azimuth 194°, distance 39.55 feet. Arrow cut in flat stone, level with surface, and 70 feet below station; azimuth 320°, distance 81.68 feet.

[Latitude 41° 18′ 05.92″. Longitude 74° 24′ 53.31.″]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
High Point	95 59 11.4	275 49 24.2	4.3181160
Writer	139 13 21.5	319 07 01.4	4.3105577
Vernon	160 21 29.5	340 17 30.6	4.3964954
Houston	192 27 20.4	12 29 31.5	4.3289821
Sterling	286 15 41.1	106 22 40.1	4.1875280
Bearfort	353 54 01.4	173 54 55.4	4.2549964

HAYES, FRANKLIN COUNTY.

A secondary station located by "three point method," about 1 mile northeast of Tupper Lake Village in an open field on a large bowlder 12 by 8 by 8 feet near hay barn and in the rear of a small log building. Land is owned by D. J. Hayes, liveryman, of Tupper Lake.

Station mark: A bronze triangulation tablet cemented in solid rock, marked "U. S. Geological Survey, New York."

[Latitude 41° 18′ 35.99″. Longitude 74° 26′ 34.80″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
St. Regis	203 57 51.0	24 02 35.0	4.34522
Ampersand	267 16 25.0	87 26 27.5	4.28293
Morris	19 21 29.5	199 20 08.0	3.89649

MORRIS, FRANKLIN COUNTY.

A high bald mountain in south end of Waverly Township, 4 miles east of Big Tupper Lake and 6 miles south of Tupper Lake Village. Best reached by driving from Tupper Lake Village to Waukesha

Hotel, thence by logging road and obscure trail to summit of mountain.

Station mark: Aluminum bolt of New York State land survey set in solid rock, also copper bolt 1 inch in diameter set in solid rock and stamped "U. S. G. S." N. Y. 497", 9⅝ inches distant from State land survey bolt. Position computed is that of State land survey bolt.

[Latitude 44° 09′ 36.18″. Longitude 74° 28′ 32.87″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
West	29 10 08.7	209 00 30.7	4.5811562
Moody	160 28 14.0	340 27 37.0	3.5479300
Azure	177 15 07.4	357 14 03.2	4.6276584
Rice	194 25 56.0	14 31 17.0	4.6070600
Hayes	199 20 08.0	19 21 30.0	3.8964900
St. Regis	202 44 15.1	22 50 21.0	4.4771258
Moose Peak	240 24 56.6	60 44 41.0	4.6357242
Ampersand	249 00 18.0	69 11 42.0	4.3677100
Seward	269 53 53.6	90 05 24.8	4.3433268
Vanderwhacker	313 34 05.6	133 49 54.6	4.6238473
Blue	349 24 34.2	169 27 89.9	4.5114860
Kempshall	322 10 24.0	142 16 28.2	4.2789159

MOODY, FRANKLIN COUNTY.

(Not occupied.)

A low bare point on the east side of Big Tupper Lake in the southwest corner of Franklin County.

Station mark: A bolt of the New York State Land Survey.

[Latitude 44° 11′ 23.01″. Longitude 74° 29′ 25.52″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
St. Regis	207 41 01	27 47 44	4.43917
Morris	340 27 37	160 28 14	3.54793

AZURE, FRANKLIN COUNTY.

On a cleared mountain locally known as Blue Mountain, about 4 miles southwest from Spring Cove Station on the New York and Ottawa Railway. A good trail from the Blue Mountain House to the summit.

Station mark: A bronze tablet cemented in solid rock marked "U. S. Geological Survey, New York."

[Latitude 44° 32′ 28.19″. Longitude 74° 30′ 04.51″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Duane M. E. Church	235 06 10.5	55 16 13.0	4.3625900
Debar	252 36 30.5	72 48 18.5	4.3676167
Rice	284 44 03.0	104 50 29.0	4.0980000
St. Regis	317 10 02.2	137 17 13.9	4.3022069
Morris	357 14 03.2	177 15 07.4	4.6276584

SOUTH HILL, ULSTER COUNTY.

(Not occupied.)

In Warwasing Township, on a sharp, round, partially cleared hill, 2 miles north of Ulster Heights post-office, on land owned by Grant Sheely, who lives 500 yards south of station.

Station mark: The rock oak signal tree.

Reference marks: Arrow cut in bowlder 6 by 5 by 3 feet; azimutn 9°, distance 45 feet. Arrow cut in bowlder 4 by 3 by 2 feet; azimuth 201°, distance 60 feet. Arrow cut in bowlder 6 by 2 by 1 feet; azimuth 245°, distance 70 feet.

[Latitude 41° 49′ 34.00″. Longitude 74° 30′ 53.68″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Walnut	78 42 43.0	258 32 31.2	4.3346119
Denman	166 10 19.4	346 09 17.6	3.9500513
Slide	208 58 49.8	29 03 59.8	4.3421254
Sams Point	322 37 17.4	142 43 36.1	4.3358465

VERNON, SULLIVAN COUNTY.

On a timbered ridge in Manakating Township, 2 miles west of New Vernon post-office.

Theodolite elevated 16 feet on stump of pine tree.

Station mark: Stump of pine tree.

Reference marks: Arrow cut in bowlder 3 by 3 by 3 feet; azimuth 247°, distance 55.95 feet. Signal tree; azimuth 152°, distance 17.88 feet. Cross (+) cut on east face of bowlder on edge 6 by 4 feet and 2 feet above ground; azimuth 144°, distance 41.18 feet. Arrow cut in south end of bowlder 4 by 5 by 3 feet; azimuth 122°, distance 54.30 feet.

[Latitude 41° 30′ 46.44″. Longitude 74° 30′ 54.49″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
High Point	29 58 07.8	209 52 18.8	4.3909515
Writer	31 51 46.7	211 49 25.0	3.9735791
Roads	105 42 44.9	285 38 24.0	3.9765996
Wolf	148 21 23.8	328 18 37.4	4.0430398
Sams Point	216 51 50.9	36 58 17.9	4.3415805
Houston	281 25 54.8	101 32 05.0	4.1219453
Eve	340 17 30.6	160 21 29.5	4.3964954

HAMBURG, SUSSEX COUNTY, N. J.

A station of the United States Coast and Geodetic Survey, situated on the Hamburg Mountains in the town of Hardiston, about 3 miles S. 76° E. from the village of Hamburg, on the New York, Susquehanna and Western Railway, about one-half mile S. 38° W. from dam at outlet of Sand Pond. On land owned by the Franklin Iron Company.

Station mark: A copper bolt three-fourths inch in diameter and 4 inches long, set in solid rock with one-half inch projecting; letters "G. S. of N. J." cut in rock on southwest side of bolt.

[Latitude 41° 08′ 53.40″. Longitude 74° 31′ 49.75″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
High Point	150 10 25.4	330 05 13.6	4.3448511
Bearfort	274 06 02.8	94 11 30.7	4.0664557
Bald Hill	323 57 21.7	144 04 26.1	4.4095860

DENMAN, SULLIVAN COUNTY.

(Not occupied.)

In Neversink Township, on a high timbered ridge known as Denman Mountain, 1¼ miles east of Clarysville post-office, on land owned by Leonard Moore, who lives one-half mile west of station.

Station mark: A copper bolt set in bowlder 10 by 10 by 8 feet on highest point of mountain, being the only bowlder on top.

Reference mark: Birch signal tree N. 68 E. 20.8 feet distant.

[Latitude 41° 54′ 14.53″. Longitude 74° 32′ 26.14″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Walnut	55 55 20.6	235 46 10.1	4.3618317
Graham			4.1781101
Sams Point	329 24 36.5	149 31 57.0	4.4778895
South Hill	346 09 17.6	166 10 19.4	3.9500513

GRAHAM, ULSTER COUNTY.

On Graham Mountain, Hardenburg Township, 3 miles south of Seager post-office, and best reached from Arkville station, on the Ulster and Delaware Railroad. The highest point is very sharp and covered with low brush, most of which was cut down in 1900. Land owned by George J. Gould, of New York City.

Station mark: A copper bolt in flat bowlder.

[Latitude 42° 02′ 22.44″. Longitude 74° 32′ 58.99″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Walnut	33 12 47.2	213 03 57.9	4.5237748
Deyoe	90 19 47.4	270 09 54.3	4.3090438
Andes	142 39 02.3	322 31 31.2	4.4051606
Utsayantha	175 14 48.4	355 13 10.9	4.6026806
Slide	288 16 41.6	108 23 15.3	4.1539652
Sams Point	338 34 47.4	158 42 30.5	4.6430438

WRITER, ORANGE COUNTY.

On a brushy ridge in Mount Hope Township, 3 miles southwest of Otisville station, on the Erie Railway, on land owned by Mr. Writer, proprietor of the Writer House, Otisville. Tenant lives 400 yards east of station. The ridge is cleared on eastern side, giving a good view in all directions.

Station mark: A copper bolt 1 inch in diameter, stamped "U.S.G.S.," set in solid rock.

Reference marks: Inch hole drilled 1 inch deep in ledge; azimuth, 148°; distance, 29.90 feet. Inch hole drilled 1 inch deep in ledge; azimuth, 16°; distance, 30.31 feet. Inch hole drilled 1 inch deep in ledge, south end; azimuth, 230°; distance, 44.80 feet.

[Latitude 41° 26′ 27.34″. Longitude 74° 34′ 28.46″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
High Point	28 45 25.1	208 41 57.3	4.1818277
Roads	158 28 59.5	338 27 00.6	4.0548316
Wolf	177 14 34.5	357 14 10.5	4.2408390
Vernon	211 49 25.0	31 51 46.7	3.9735791
Houston	253 18 36.1	73 27 08.3	4.2725795
Eve	319 07 01.4	139 13 21.5	4.3105577

WOLF, SULLIVAN COUNTY.

In Thompson Township, on a timbered ridge 1 mile northwest of Wolf Pond, on land owned by the Sullivan County Club. A good view can be had in all directions.

Theodolite elevated 18½ feet on stump of tree.

Station mark: A pine tree 12 inches in diameter 3 feet above ground, having a pile of stone 6 feet in diameter and 3 feet high piled about it.

Reference marks: Arrow cut in ledge, 3 by 2 feet, a very little above surface; azimuth, 235°; distance, 43.82 feet. Arrow cut in bowlder 4 by 3 by 2 feet; azimuth, 341°; distance, 13.75 feet.

[Latitude 41° 35′ 51.07″. Longitude 74° 35′ 04.62″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
High Point	11 53 48.5	191 50 44.3	4.4968098
Roads	25 55 18.2	205 53 43.1	3.8809053
Monticello	129 54 19.4	309 50 25.2	4.0268466
Walnut	143 56 28.8	323 49 05.3	4.4175630
Sams Point	246 39 29.6	66 48 34.2	4.3149145
Vernon	328 18 37.4	148 21 23.3	4.0430398
Writer	357 14 10.5	177 14 34.5	4.2408390

UTSAYANTHA, DELAWARE COUNTY.

A station of the New York State survey 1 mile (air line) southeast of Stamford.

Theodolite elevated 60 feet in an observatory 49.3 feet distant from station. True azimuth from station, 197° 25′.

Station mark: A copper bolt set in solid rock 18 inches below surface of ground, above which is a granite post 18 by 6 by 6 inches marked "N. Y. S. S. 27."

[Latitude 42° 23′ 56.21″. Longitude 74° 35′ 24.12″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Andes	31 31 09.9	211 25 15.0	4.3641901
Bramley	59 06 48.4	238 57 34.9	4.3410478
Meredith	91 17 51.2	271 05 06.7	4.4133899
Hooker	134 05 00.6	313 53 52.2	4.4969308
Otsego	167 37 46.6	347 33 08.8	4.6390267
Slide	339 10 51.4	159 19 04.0	4.6765330
Graham	355 13 10.9	175 14 48.4	4.6026806
Telford	127 39 12.0	307 16 39.4	4.7595348

HIGH POINT, SUSSEX COUNTY, N. J.

A station of the United States Coast and Geodetic Survey, in Montague Township, 4 miles south of Port Jervis, on the highest land in the State.

Station mark: A copper bolt set in solid rock.

[Latitude 41° 19′ 15.29″. Longitude 74° 39′ 42.86″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Walnut	170 11 05.9	350 06 48.2	4.7211823
Roads	187 27 33.4	7 29 02.6	4.3817799
Wolf	191 50 44.3	11 53 48.5	4.4968100
Writer	208 41 57.3	28 45 25.1	4.1818277
Vernon	209 52 18.3	29 58 07.8	4.3909515
Sams Point	213 07 28.5	33 18 35.9	4.6672128
Houston	233 25 04.0	53 37 03.5	4.4973076
Eve	275 49 24.2	95 59 11.4	4.3181160
Sterling	280 11 32.0	100 28 18.1	4.5570329
Bearfort	311 25 25.5	131 36 05.8	4.4802442
Hamburg	330 05 13.6	150 10 25.4	4.3448511

MONTICELLO, SULLIVAN COUNTY.

(Not occupied.)

Station mark: Standpipe at Monticello.

[Latitude 41° 39′ 32.12″. Longitude 74° 40′ 57.31″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sams Point	267 04 09.7	87 17 09.0	4.4338327
Wolf	309 50 25.2	129 54 19.4	4.0268466

OTSEGO, OTSEGO COUNTY.

A station of the United States Coast and Geodetic Survey and of the New York State survey, in Cherry Valley Township, on a high ridge 3 miles east from the village.

Station mark: A granite post, 48 by 6 by 6 inches, set 42 inches in the ground, marked "N. Y. S. S. 26."

[Latitude, 42° 46′ 54.73″. Longitude, 74° 42′ 14.60″.]

Station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wart	72 05 40.2	251 52 56.0	4.4302101
Telford	78 19 18.7	258 01 19.8	4.5674238
Tassel Hill	109 41 58.7	289 16 58.2	4.7252676
Utsayantha	347 33 08.8	167 37 46.6	4.6390267

WEST MOUNTAIN, HAMILTON COUNTY.

A dome-topped mountain in the town of Long Lake, on the west side of Raquette Lake. Summit entirely cleared. Is best reached from Antlers Hotel, Raquette Lake, by small boat to trail near house of Mr. Blanchard on north side of Sucker-brook Bay, thence 4 miles to summit of mountain. Water within one-half mile of top.

Station mark: A copper bolt cemented in rock on highest point. Station number, 494.

[Latitude 43° 51′ 35.87″. Longitude 74° 42′ 24.31″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Stillwater	90 33 18.8	270 19 42.3	4.4201784
Webb	133 53 48.4	313 45 37.6	4.3400136
Morris	209 00 30.7	29 10 08.7	4.5811562
Kempshall	238 41 35.4	58 57 16.0	4.5481265
Blue	266 38 52.0	86 51 33.8	4.3906718

ANDES, DELAWARE COUNTY.

On a prominent timbered mountain locally called Mount Pisgah, in town of Andes, and owned by Elliott Graham. Most of the timber was cut down in 1900, one birch tree being left for a signal.

Station mark: A bronze triangulation tablet cemented in a large flat bowlder on highest point of mountain.

Reference mark: The birch signal tree; true azimuth, mark to tree, 110° 04′ distance 57 feet.

[Latitude 42° 13′ 16.81″. Longitude 74° 44′ 11.38″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Deyoe	13 43 09.3	193 40 46.2	4.3157762
Butternut	123 27 10.9	303 06 51.2	4.6953369
Bramley	141 24 30.8	321 21 12.8	4.0337993
Meredith	145 37 50.7	325 31 02.4	4.3904270
Utsayantha	211 25 15.0	31 31 09.9	4.3641901
Slide	310 18 47.4	130 32 52.6	4.5803074
Graham	322 31 31.2	142 39 02.3	4.4051606
Willis	87 13 22.4	266 48 12.8	4.7127779

WALNUT, SULLIVAN COUNTY.

On the highest point of Walnut Mountain, in Liberty Township, 1¼ miles southwest of Liberty and 500 feet north of the Walnut Mountain House. A good view can be had in all directions.

Theodolite elevated 36 feet.

Station mark: A bronze triangulation tablet cemented in solid rock level with surface.

Reference marks: Arrow cut in ledge east edge of ridge; azimuth 326°, distance 130.05 feet. Arrow cut in ledge west edge of ridge; azimuth 74°, distance 71.42 feet.

[Latitude 41° 47′ 15.90″. Longitude 74° 46′ 11.34″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
White Lake	23 31 16.3	203 28 34.7	4.1481635
Knack	92 17 00.9	272 08 34.4	4.2445692
Maulik	125 49 19.9	305 41 52.5	4.2803796
Deyoe	175 37 19.6	355 36 17.2	4.4493156
Graham	213 03 57.9	33 12 47.2	4.5237748
Slide	233 26 44.2	53 42 07.4	4.5971647
Denman	235 46 10.1	55 55 20.6	4.3618317
South Hill	258 32 31.2	78 42 43.0	4.3346119
Sams Point	290 32 56.2	110 49 25.5	4.5648950
Wolf	323 49 05.3	143 56 28.8	4.4175630
High Point	350 06 48.2	170 11 05.9	4.7211823

DEYOE, DELAWARE COUNTY.

On a heavily timbered ridge, property of New York State, 2 miles northwest of Lewbeach post-office.

Best reached from Rockland, a station on the New York, Ontario and Western Railway. E. D. Deyoe lives 1 mile south of station.

Theodolite elevated 25 feet on stump of tree.

Station mark: Stump of maple tree, 18 inches in diameter, 25 feet high. Six lines were cut through timber to as many different stations.

[Latitude 42° 02′ 25.29″. Longitude 74° 47′ 44.73″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Maulik	38 13 30.4	218 07 04.3	4.3326800
Starkweather	114 46 08.0	294 35 52.3	4.3661821
Bramley	176 16 54.6	356 16 00.3	4.4564693
Andes	193 40 46.2	13 43 09.3	4.3157762
Graham	270 09 54.3	90 19 47.4	4.3090438
Walnut	355 36 17.2	175 37 19.6	4.4493156

BRAMLEY, DELAWARE COUNTY.

On a high bare ridge in Delhi Township, 2½ miles south of Bloomville, on land owned by S. G. Bramley.

Station mark: A bronze triangulation tablet cemented in solid rock, 6 inches below surface of ground.

[Latitude 42° 17′ 50.53″. Longitude 74° 49′ 05.72″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Starkweather	45 38 13.7	225 28 50.9	4.4299297
Loomis	76 02 60.0	255 47 35.1	4.5118611
Meredith	148 52 42.2	328 49 11.8	4.1403248
Utsayantha	238 57 34.9	59 06 48.4	4.3410478
Andes	321 21 12.8	141 24 30.8	4.0337993
Deyoe	356 16 00.3	176 16 54.6	4.4564693
Persons	113 30 42.9	293 21 14.0	4.3237562

WHITE LAKE, SULLIVAN COUNTY.

(Not occupied.)

In Bethel Township, on a timbered ridge at south end of White Lake, on land owned by N. Goldsmith, who lives 300 yards southeast of station. A wooden tower in field about 300 yards west of station gives a good view from N. 20° E. around by west to south.

Station mark: Center of hemlock tree 14 inches in diameter 3 feet above ground, having a mound of stones 5 feet in diameter and 3 feet high piled about it.

Reference marks: Arrow cut in north end of the only large bowlder on hill; azimuth 23°, distance 279.60 feet. Arrow cut in bowlder 16 by 3 by 2 feet; azimuth 157°, distance 82.75 feet.

[Latitude 41° 40′ 17.80″. Longitude 74° 50′ 14.00″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Knack	138 40 50.0	318 35 05.6	4.2574751
Maulik	157 41 23.4	337 36 38.2	4.4149285
Walnut	203 28 34.7	23 31 16.3	4.1481635

HOOKER, OTSEGO COUNTY.

On a high, bare knob in Maryland Township, 3½ miles west of Schenevus, on land owned by E. D. Hooker (post-office, Westville).

Station mark: A granite post 48 by 6 by 6 inches, set 42 inches in the ground, marked "N. Y. S. S. 409."

[Latitude 42° 35′ 43.00″. Longitude 74° 51′ 53.44″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Meredith	8 49 50.2	188 48 12.6	4.3329191
Telford	119 50 46.5	299 39 21.7	4.4234765
Wart	134 54 35.7	314 48 24.9	4.2450464
Utsayantha	313 53 52.2	134 05 00.6	4.4969308

WEBB, HERKIMER COUNTY.

On high, timbered mountain, 3 miles southwest of Gull Lake and 1 mile east of Long Lake, on land owned by H. Seward Webb.

Can be reached by going to Bartlow Junction, on Mohawk and Malone Railroad, thence by private railroad to Waterkirks mill, thence by trail to Gull Lake, thence by Gull Lake and Long Pond trail to west boundary of Webb's reserve, thence south along line to summit of ridge (one-half mile), thence east about 700 feet to signal.

Theodolite elevated 30 feet.

Station mark: High stump of tree, which was used as support for theodolite.

[Latitude 43° 59′ 46.77″. Longitude 74° 54′ 11.84″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Morris	241 55 11.4	62 13 02.3	4.5885043
West	313 45 37.6	133 53 48.4	4.3400136

MEREDITH, DELAWARE COUNTY.

On a high, bare knob about 2 miles southwest of East Meredith, in Meredith Township, on land belonging to Finley Gilchrist.

Station mark: A marble post, 28 by 6 by 6 inches, set 24 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 42° 24′ 13.69″. Longitude 74° 54′ 17.93″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Willis	58 43 52.5	238 25 28.4	4.6437972
Starkweather	21 29 20.3	201 23 26.9	4.5177814
Loomis	51 04 52.6	230 52 57.0	4.4960309
Butternut	104 16 10.6	284 02 38.0	4.4531355
Telford	150 13 42.7	330 03 56.9	4.5987214
Hooker	188 48 12.6	8 49 50.2	4.3329191
Utsayantha	271 05 06.7	91 17 51.2	4.4138899
Andes	325 31 02.4	145 37 50.7	4.3904270
Bramley	328 49 11.8	148 52 42.2	4.1403248

MAULIK, SULLIVAN COUNTY.

On a partially cleared ridge in Freemont Township, 3 miles southwest of Rockland Village, on the New York, Ontario and Western Railway, on land owned by John Maulik, who lives one-fourth mile southwest of station.

Station mark: Center of maple tree, 2 feet in diameter, cut off for instrument support 28 feet above ground.

Reference marks: Arrow cut in large bowlder; azimuth 322°, distance 7.86 feet. Arrow cut in ledge, south side of ridge; azimuth 81°, distance 75.77 feet. Arrow cut in flat bowlder; azimuth 166°, distance 49.87 feet.

[Latitude 41° 53′ 17.14″. Longitude 74° 57′ 22.07″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Knack	11 08 31.8	191 07 32.3	4.0280701
Deyoe	218 07 04.3	38 13 30.4	4.3326800
Walnut	305 41 52.5	125 49 19.9	4.2803796
White Lake	337 36 38.2	157 41 23.4	4.4149285

KNACK, SULLIVAN COUNTY.

In Delaware Township, on a partially-cleared ridge 2 miles west of the village of Jeffersonville, on land owned by Peter Knack, who lives 200 yards east of station.

Station mark: A bronze triangulation tablet cemented in solid rock 4 by 3 feet by 1 foot.

Reference marks: Arrow cut in rock 10 by 15 by 2 feet; azimuth 105°, distance 33 feet. Arrow cut in rock on east side of ridge; azimuth 47°, distance 75 feet. Arrow cut in rock very little above surface; azimuth 34°, distance 70 feet.

[Latitude 41° 47′ 37.88″. Longitude 74° 58′ 51.35″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Maulik	191 07 32.3	11 08 31.8	4.0280701
Walnut	272 08 34.4	92 17 00.9	4.2445692
White Lake	318 35 05.6	138 40 50.0	4.2574751

WART, OTSEGO COUNTY.

On a bare knoll of cultivated land owned by T. T. Thompson, 5 miles west of Cooperstown, in Otsego Township. The station is in the southeast corner of field, about 8 feet from the fence.

Station mark: A stone post 36 by 6 by 6 inches set 28 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 42° 42′ 24.89″. Longitude 75° 01′ 00.54″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Telford	94 08 39.9	274 03 25.5	4.0242858
Otsego	251 52 56.0	72 05 40.2	4.4302101
Hooker	314 48 24.9	134 54 35.7	4.2450464

STILLWATER, HERKIMER COUNTY.

On Stillwater Mountain, about 11 miles west of Beaver station, on Mohawk and Malone Railway, and 2 miles southwest of the stillwater in Beaver River.

Station mark: A bronze triangulation tablet cemented in solid rock.

[Latitude 43° 51′ 42.44″. Longitude 75° 02′ 02.20″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Schwartz	45 18 33.0	225 06 29.5	4.5182215
Gum	56 42 33.8	236 23 57.4	4.6363342
Rock	71 51 40.6	169 37 16.7	4.4461049
Alder	121 24 06.2	301 19 41.7	3.9989646
Morris	233 19 38.8	53 42 55.4	4.7457777
West	270 19 42.3	90 33 18.8	4.4201784

STARKWEATHER, DELAWARE COUNTY.

On a partially cleared ridge in Walton Township, 6 miles southeast of Walton, on land owned by J. H. Starkweather, who lives one-half mile east of station.

Station mark: A bronze tablet cemented in bowlder 4 by 3 by 2 feet.

Reference marks: Arrow cut in ledge; azimuth 50°, distance 113.10 feet. Arrow cut in ledge; azimuth 110°, distance 75.17 feet. Arrow cut in ledge; azimuth 185°, distance 31.15 feet.

[Latitude 42° 07′ 39.85″. Longitude 75° 03′ 03.35″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Rockrift	79 47 14.9	259 40 09.7	4.1704092
Loomis	131 36 04.7	311 30 03.7	4.2172014
Meredith	201 23 26.9	21 29 20.3	4.5177814
Bramley	225 28 50.9	45 38 13.7	4.4299297
Deyoe	294 35 52.3	114 46 08.0	4.3661821

PERSONS, DELAWARE COUNTY.

(Not occupied.)

On a round, bare knoll in Franklin Township, on land owned by A. R. Persons (Treadwell post-office).

Station mark: A bronze tablet cemented in solid rock 15 inches below surface of ground and covered with a small pile of flat stones.

[Latitude 42° 22′ 22.15″. Longitude 75° 03′ 10.37″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Butternut	124 07 36.1	304 00 03.0	4.2681221
Meredith	254 10 13.3	74 16 12.3	4.1022924
Bramley	293 21 14.0	113 30 42.9	4.3237562

MYERS, ONEIDA COUNTY.

A low, partially cleared hill, 6 miles northeast of Forestport, locally known as "Myers Hill." The Herkimer-Oneida county line passes over the hill about 1,000 feet east of station.

Station mark: A copper bolt marked "U. S. G. S. N. Y. 487" set in solid rock.

[Latitude 43° 28′ 39.82″. Longitude 75° 06′ 01.72″.]

To station—	Azimuth.	Back azimuth.	Log. distance
	° ′ ″	° ′ ″	*Meters.*
Schuyler	2 07 08.5	182 06 29.1	4.5450250
Penn	49 54 30.9	229 47 55.8	4.2281188
Boonville	90 50 27.0	270 41 15.1	4.2559318
Gum	121 30 13.6	301 14 26.1	4.5579931
Schwartz	137 06 45.4	316 57 29.4	4.4242541

ALDER, HERKIMER COUNTY.

On Alder Creek Mountain, about 23 miles east of Lowville and 5 miles northeast of Number Four post-office. Can be reached by following Alder Creek trail northeast from Number Four post-office about 3 miles, thence east 2 miles to signal.

Station mark: A copper bolt cemented in solid rock.

[Latitude 43° 54′ 30.68″. Longitude 75° 08′ 23.79″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Schwartz	27 39 52.0	207 32 12.2	4.5061884
Gum	43 37 18.7	223 23 05.7	4.6025889
Rock	52 18 27.6	232 09 09.7	4.3572002
Elmer	77 08 05.2	256 49 08.1	4.5752192
Stillwater	301 19 41.7	121 24 06.2	3.9989646

TELFORD, OTSEGO COUNTY.

On a knob, cleared on south end but heavily timbered on north end, in Burlington Township 6 miles east of Edmeston and 10 miles west of Cooperstown. The land is owned by S. W. Telford.

Station mark: A copper bolt set in solid rock 1 foot below surface of ground, above which is a red sandstone block 15 by 11 by 11 inches, in center of top of which is cemented a bronze triangulation tablet.

[Latitude 42° 42′ 49.40″. Longitude 75° 08′ 44.06″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Butternut	15 42 04.0	195 38 15.2	4.4555214
Sherburne	69 22 27.2	249 10 52.8	4.3969063
Otsego	258 01 19.8	78 19 18.7	4.5674238
Wart	274 03 25.5	94 08 39.9	4.0242858
Hooker	299 39 21.7	119 50 46.5	4.4234765
Utsayantha	307 16 39.4	127 39 12.0	4.7595348
Meredith	330 03 56.9	150 13 42.7	4.5987214

LITCHFIELD, HERKIMER COUNTY.

In Litchfield Township, one-half mile north of Jerusalem Church, on a cultivated bare hill owned by H. Wheelock.

Station mark: A stone post 30 by 8 by 6 inches, set 28 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 42° 59′ 05.65″. Longitude 75° 08′ 44.168″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Plainfield	10 03 22.7	190 01 40.3	4.2918608
Tassel	70 59 03.1	250 52 03.1	4.1696687
Schuyler	186 52 09.4	6 53 21.2	4.2975436

PLAINFIELD, OTSEGO COUNTY.

On a bald ridge owned by J. J. Roberts in town of Plainfield, 1¼ miles south of Plainfield Center. Some timber still standing on western end of ridge.

Station mark: A blue stone post 36 by 6 by 6 inches, set 22 inches in the ground and resting on solid rock. In the center of top of post is cemented a bronze triangulation tablet.

[Latitude 42° 48′ 40.79″. Longitude 75° 11′ 14.66″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Tassel	143 51 27.3	323 46 10.4	4.2530080
Litchfield	190 01 40.3	10 03 22.7	4.2918608

LOOMIS, DELAWARE COUNTY.

On a partially cleared ridge in Walton Township about 5 miles northwest of Walton and three-fourths of a mile north of Loomis post-office. Land owned by Mr. Allen, of Walton.

Station mark: A copper bolt set in bowlder level with surface of ground.

Reference marks: Six-inch spike driven in center of blaze on lone wild cherry tree in field; azimuth 194°, distance 664.30 feet. Six-inch spike driven in blaze on oak tree 8 inches in diameter; azimuth 346°, distance 123.35 feet.

[Latitude 42° 13′ 34.33″. Longitude 75° 12′ 01.02″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Rockrift	9 16 17.1	189 15 12.3	4.1384968
Willis	76 20 58.7	256 14 30.8	4.1345778
Meredith	230 52 57.0	51 04 52.6	4.4960309
Bramley	255 47 35.1	76 02 60.0	4.5118611
Starkweather	311 30 03.7	131 36 04.7	4.2172014

ROCKRIFT, DELAWARE COUNTY.

(Not occupied.)

On a high timbered ridge in Walton Township.

Station mark: Hemlock signal tree, 2 feet in diameter, with two notches cut on north and south face, and a mound of stone 6 feet in diameter and 3 feet high piled around it.

Reference marks: Six-inch spike driven in center of blaze on maple tree; azimuth 35°, distance 41.93 feet. Six-inch spike driven in center of blaze on beech tree 10 inches diameter; azimuth 117°, distance 28.34 feet. Six-inch spike driven in center of blaze on rock-oak tree 16 inches diameter; azimuth 205°, distance 46.23 feet.

[Latitude 42° 06′ 14.29″. Longitude 75° 13′ 37.48″].

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Willis	133 10 53.3	313 05 30.6	4.1799136
Loomis	189 15 12.3	9 16 17.1	4.1384968
Starkweather	259 40 09.7	79 47 14.9	4.1704092

BUTTERNUT, OTSEGO COUNTY.

On a cleared knob in Butternut Township, on land owned by Walter Wood and occupied by Mr. Foote.

Station mark: A marble post 36 by 6 by 6 inches, set 32 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "New York 517."

[Latitude 42° 27′ 58.70″. Longitude 75° 14′ 22.18″].

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Willis	18 30 41.8	198 25 48.0	4.4986447
Bobell	59 42 52.4	239 25 01.1	4.6251388
Whitcomb	81 29 42.1	261 18 39.1	4.3560978
Sherburne	140 03 35.8	319 55 51.7	4.3866556
Telford	195 38 15.2	15 42 04.0	4.4555214
Meredith	284 02 38.0	104 16 10.6	4.4531355
Andes	303 06 51.2	123 27 10.9	4.6955369

PENN, ONEIDA COUNTY.

A United States Coast and Geodetic Survey station, on a bare hill in Steuben Township, about 2 miles west of Steuben station.

Station mark: A granite post marked $\frac{\text{U}|\text{S}}{\text{S}|\text{C}}$, with four granite witness posts.

[Latitude 43° 22′ 46.56″. Longitude 75° 15′ 36.36″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gum	148 54 29.0	328 45 18.0	4.5407023
Boonville	155 21 42.2	335 19 05.8	4.0885049
Schwartz	170 16 34.5	350 13 54.7	4.4883160
Myers	229 47 55.8	49 54 30.9	4.2281188
West Canada	249 30 13.7	69 52 17.9	4.6642805
Fort Noble	264 17 01.0	84 34 59.0	4.5500200
Hamilton	266 52 46.9	87 29 36.5	4.8601480
West Creek	280 50 11.0	101 13 37.0	4.6719400
Schuyler	334 10 19.3	154 16 17.0	4.4284693

TASSEL, ONEIDA COUNTY.

A station of the United States Coast and Geodetic Survey and of the New York State survey, in Marshall Township, 5 miles east of Waterville.

Station mark: A granite post 48 by 6 by 6 inches, set 44 inches in the ground, and marked "N. Y. S. S. 29."

[Latitude 42° 56′ 29.13″. Longitude 75° 19′ 00.48″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Schuyler	213 34 46.8	33 42 59.6	4.4692854
Litchfield	250 52 03.1	70 59 03.1	4.1696687
Plainfield	323 46 10.4	143 51 27.8	4.2530080

BOONVILLE, ONEIDA COUNTY.

A high cleared hill in Boonville Park.

Station mark: Flagstaff in park.

[Latitude 43° 28′ 47.61″. Longitude 75° 19′ 23.79″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Myers	270 41 15.1	90 50 27.0	4.2559318
Penn	335 19 05.8	155 21 42.2	4.0885049

SCHWARTZ, LEWIS COUNTY.

On high ground one-half mile east of Schwartz schoolhouse in Greig Township.

Theodolite elevated 50 feet.

Station mark: A granite post in top of which is cemented a copper bolt.

[Latitude 43° 39′ 09.63″. Longitude 75° 19′ 28.37″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gum	87 15 20.8	267 08 48.6	4.1055027
Elmer	132 30 13.8	312 18 58.8	4.4710612
Rock	167 43 45.6	347 42 08.2	4.1709796
Alder	207 32 12.2	27 39 52.0	4.5061884
Stillwater	225 06 29.5	45 18 33.0	4.5182215
Myers	316 57 29.4	137 06 45.4	4.4242541
Penn	350 13 54.7	170 16 34.5	4.4883160

WILLIS, DELHI COUNTY.

On the summit of a bare flat ridge in the town of Masonville, 3 miles south of the village.

Station mark: A marble post, 16 by 7 by 7 inches, set 24 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 42° 11′ 49.65″. Longitude 75° 21′ 38.42″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bobell	107 59 21.4	287 46 26.2	4.4438558
Whitcomb	154 47 29.0	334 41 21.3	4.4669983
Butternut	198 25 48.0	18 30 41.8	4.4986447
Meredith	238 25 28.4	58 43 52.5	4.6137972
Loomis	256 14 30.8	76 20 58.7	4.1345778
Andes	266 48 12.8	87 13 22.4	4.7127779
Rockrift	313 05 30.6	133 10 53.3	4.1799136

ROCK, LEWIS COUNTY.

A high, rocky point in Watson Township, 8 miles east of Lowville, on land owned by George Venatti.

Station mark: A bronze triangulation tablet cemented in solid rock.

[Latitude 43° 46′ 58.98″. Longitude 75° 21′ 49.26″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gum	32 23 03.2	212 18 07.9	4.2524113
Elmer	106 24 11.0	286 14 32.9	4.2890136
Croghan	169 37 16.7	349 36 07.9	4.0906550
Alder	232 09 09.7	52 18 27.6	4.3572002
Stillwater	251 37 58.6	71 51 40.6	4.4461049
Schwartz	347 42 08.2	167 43 45.6	4.1709796

CROGHAN, LEWIS COUNTY.

Catholic church in the village of Croghan.

Station mark: Stone tower on church.

[Latitude 43° 53′ 31.64″. Longitude 75° 23′ 28.71″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gum			4.4501663
Elmer	68 01 58.6	247 53 28.7	4.2486477
Rock	349 36 07.9	169 37 16.7	4.0906550

SHERBURNE, CHENANGO COUNTY.

On a long bare hill owned by Nicholas Richards, in the extreme southeastern corner of the town of Sherburne.

Station mark: A bowlder 24 by 10 by 10 inches sunk 24 inches in the ground.

[Latitude 42° 88′ 03.40″. Longitude 75° 25′ 48.51″.]

To station--	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Whitcomb	17 03 37.4	197 00 17.2	4.3629384
Berry	66 23 09.5	246 12 35.3	4.3680101
Smyrna	109 43 51.3	289 34 43.9	4.2907616
Telford	249 10 52.8	69 22 27.2	4.3979063
Butternut	319 55 51.7	140 03 35.8	4.3866556

GUM, LEWIS COUNTY.

On a high, cleared point in Turin Township, about 4 miles northwest of Turin Village, on land owned by Thomas Evans, who lives 2,000 feet east of station.

Station mark: A stone post 48 by 8 by 8 inches, set flush with surface of ground; in the center of top is cemented a bronze triangulation tablet.

[Latitude 43° 38′ 49.46″. Longitude 75° 28′ 56.60″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Rock	212 18 07.9	32 23 03.2	4.2524113
Alder	223 23 05.7	43 37 18.7	4.6025889
Stillwater	236 23 57.4	56 42 33.8	4.6363342
Schwartz	267 08 48.6	87 15 20.8	4.1055027
Myers	301 14 26.1	121 30 13.6	4.5579931
Penn	328 45 18.0	148 54 29.0	4.5407023

WHITCOMB, CHENANGO COUNTY.

On the south end of a hill in the town of Guilford and on the west side of north pond.

Station mark: A cut bluestone post 48 by 6 by 6 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, marked "New York 518."

[Latitude 42° 26' 08.71". Longitude 75° 30' 44.55".]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ' "	° ' "	*Meters.*
Bobell	37 45 58.1	217 39 09.0	4.3564016
Berry	130 56 19.9	310 49 06.8	4.2869704
Sherburne	197 00 17.2	17 03 37.4	4.3629384
Butternut	261 18 39.1	81 29 42.1	4.3560978
Willis	334 41 21.3	154 47 29.0	4.4669983

ELMER, LEWIS COUNTY.

Seven miles northwest of Lowville, in town of Harrisburg, 1 mile south of Harrisburg post-office, on land owned by E. P. Elmer.

Station mark: A marble post 48 by 8 by 8 inches, set flush with surface of ground, in center of top of which is cemented a bronze triangulation tablet.

[Latitude 43° 49' 56.12". Longitude 75° 35' 44.54".]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ' "	° ' "	*Meters.*
Croghan	247 53 28.7	68 01 58.6	4.2486477
Alder	256 49 08.1	77 08 05.2	4.5752192
Rock	286 14 32.9	106 24 11.0	4.2890136
Schwartz	312 18 58.8	132 30 13.8	4.4710612

SMYRNA, CHENANGO COUNTY.

On the highest point of a bare hill in the town of Smyrna, 4 miles west of the village.

Station mark: A bluestone post 48 by 6 by 6 inches, set 30 inches in the ground (resting on solid rock), in the center of the top of which is cemented a bronze triangulation tablet.

[Latitude 42° 41' 36.32". Longitude 75° 39' 16.21".]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ' "	° ' "	*Meters.*
Berry	10 29 21.3	190 27 53.7	4.2100681
Sherburne	289 34 43.9	109 43 51.3	4.2907616

BOBELL, CHENANGO COUNTY.

A station of the New York State survey, situated on the highest point of a bare hill, in the town of Coventry, 4 miles south and 1 mile east of the village.

Station mark: A granite post of the New York State survey marked "N. Y. S. S. 390."

[Latitude 42° 16′ 26.18″. Longitude 75° 40′ 51.75″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Windsor	15 53 33.8	195 50 55.6	4.2956850
Maine	76 38 30.0	256 26 28.6	4.4029914
Virgil	122 53 27.9	302 34 53.6	4.6527993
Berry	178 33 16.1	358 32 53.2	4.4865173
Whitcomb	217 39 09.0	37 45 58.1	4.3564016
Willis	287 46 26.2	107 59 21.4	4.4438558
Butternut	239 25 01.1	59 42 52.4	4.6251388

BERRY, CHENANGO COUNTY.

A station of the New York State survey, on the town line between Pharsalia and McDonough, 1½ miles east of East Pharsalia.

Station mark: A granite post marked "N. Y. S. S. 381."

[Latitude 42° 32′ 59.40″. Longitude 75° 41′ 25.64″.]

To station—	Azimuth	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Virgil	80 25 34.2	260 07 19.8	4.5740224
Solon	109 51 50.1	289 39 49.6	4.4115321
Smyrna	190 27 53.7	10 29 21.3	4.2100681
Sherburne	246 12 35.3	66 23 09.5	4.3680101
Whitcomb	310 49 06.8	130 56 19.9	4.2869705
Bobell	358 32 53.2	178 33 16.1	4.4865173

WINDSOR, BROOME COUNTY.

A station of the New York State survey, situated on the highest part of a timbered hill, one-half mile north and 1 mile east of West Windsor.

Station mark: A broken granite post of the New York State survey.

[Latitude 42° 06′ 10.26″. Longitude 75° 44′ 47.29″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Ely	97 31 41.6	277 24 41.3	4.1620909
Maine	124 22 43.3	304 13 21.2	4.3668694
Virgil	143 16 17.9	323 00 23.8	4.7334862
Bobell	195 50 55.6	15 53 33.8	4.2956850

M'DONOUGH, CHENANGO COUNTY.

A secondary station, on a comparatively low hill in McDonough Township, about 10 miles west of Oxford and one-half mile west of McDonough village, on land owned by George Jones. The view is partly cut off by timber and higher hills.

Station mark: A pole 6 inches in diameter set in ground and resting on a bowlder 18 inches under ground, on upper surface of which a triangle was cut.

Reference marks: Stone wall 266 feet east. Stone wall 204 feet west.

[Latitude 42° 29′ 55.38″. Longitude 75° 47′ 13.87″.]

To station–	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Berry	234 25 26.9	54 29 22.2	3.9898161
Bobell	340 40 10.4	160 44 28.0	4.4224870
Beadle	358 31 39.9	178 31 48.5	4.0396390

BEADLE, CHENANGO COUNTY.

On a bare hill in Smithville Township, 1½ miles northwest of Smithville Flats, on land belonging to H. C. Beadle.

Station mark: A bluestone post 30 by 7 by 7 inches set 30 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 42° 24′ 00.40″. Longitude 75° 47′ 01.60″.

To station–	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
McDonough	178 31 48.5	358 31 39.9	4.0396390
Berry	204 44 20.5	24 48 07.4	4.2628410
Bobell	328 49 36.8	148 53 45.9	4.2141530

ELY, BROOME COUNTY.

An observation tower on the first hill northwest of the city of Binghamton.

Station mark: Center of observatory.

Reference mark: A granite post 48 by 6 by 6 inches set 42 inches in the ground, 35 feet south of observatory, and marked "N. Y. S. S. 417."

[Latitude 42° 07′ 11.47″. Longitude 75° 55′ 14.10″.]

To station–	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Maine	156 42 55.5	336 40 34.0	4.0872424
Windsor	277 24 41.3	97 31 41.6	4.1620909

BLOODY POND, CORTLAND COUNTY.

A secondary station in the northwest corner of the town of Willet, on the highest point of the hill to the northwest of Bloody Pond.

Station mark: A cut marble post, 30 by 6 by 6 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "New York 519."

[Latitude 42° 29′ 21.22″. Longitude 75° 57′ 38.14″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Berry	253 02 15.6	73 13 12.8	4.3654326
Bobell	315 59 36.7	136 10 55.1	4.5210775

MAINE, BROOME COUNTY.

A station of the New York State survey on a bare hill in the eastern part of the town of Maine.

Station mark: A granite post, 48 by 6 by 6 inches, marked "N. Y. S. S. 398."

[Latitude 42° 13′ 15.35″. Longitude 75° 58′ 44.81″.]

To station–	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Virgil	156 19 15.5	336 12 44.6	4.5183599
Bobell	256 26 28.6	76 38 30.0	4.4029914
Windsor	304 13 21.2	124 22 43.3	4.3668693
Ely	336 40 34.0	156 42 55.5	4.0872424

VIRGIL, CORTLAND COUNTY.

A station of the New York State survey in Virgil township.

Station mark: A granite post, 48 by 6 by 6 inches, set 42 inches in the ground, marked "N. Y. S. S. 402."

[Latitude 42° 29′ 34.07″. Longitude 76° 08′ 24.96″.]

To station–	Azimuth.	Back azimuth.	Log. distance
	° ′ ″	° ′ ″	*Meters.*
Solon	219 59 02.5	40 05 17.6	4.2937235
Berry	260 07 19.8	80 25 34.2	4.5740224
Bobell	302 34 53.6	122 53 27.9	4.6527993
Maine	336 12 44.6	156 19 15.5	4.5183599
Warren	3 16 28.7	183 14 55.3	4.7478659

Primary Traverse.

Geographic positions along Ogdensburg and Lake Champlain Railway from Ogdensburg to Churubusco.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Ogdensburg, light-house at (United States lake survey)	44 41 52.3	75 30 14.0
Milepost 114, road crossing 1,000 feet east of	44 42 52.4	75 25 06.0
Milepost 111, road crossing 425 feet west of	44 43 22.6	75 21 51.0
Lisbon station	44 43 38.4	75 19 09.6
Milepost 107, road crossing 205 feet east of	44 43 34.0	75 16 27.4
Milepost 105, road crossing 1,555 feet east of	44 43 41.7	75 14 06.3
Milepost 102, road crossing 250 feet west of	44 43 58.3	75 10 50.6
Madrid station, road crossing 285 feet west of	44 44 10.0	75 08 52.1
Trout Brook, road crossing 1,225 feet west of	44 44 07.4	75 06 18.5
Milepost 96, road crossing 1,540 feet east of	44 44 24.7	75 03 12.2
Norwood station, 4,200 feet west of: copper bolt set in south end of east abutment of bridge over Raquette River, 10¼ feet south of center of track	44 44 54.9	75 00 22.2
Norwood station, 2,400 feet west of; copper bolt in ledge of rock in bank, 11.8 feet north of center of track and 74.5 feet from milepost 93	44 44 59.5	74 59 58.0
Norwood station, about one-fourth mile east of, Rome, Watertown and Ogdensburg Railway crossing	44 45 08.2	74 59 08.6
Knapp station	44 46 01.2	74 56 10.2
Milepost 87, road crossing 860 feet west of	44 46 49.0	74 53 16.5
Milepost 85, road crossing 2,080 feet east of	44 47 16.4	74 50 12.8
Winthop and Brasher station, 585 feet east of, west end of bridge over St. Regis River	44 47 39.1	74 47 09.0
Milepost 81, road crossing 2,750 feet east of	44 47 45.8	74 45 12.9
Milepost 79, road crossing 1,120 feet east of	44 47 58.2	74 43 09.8
Milepost 77, road crossing 960 feet east of	44 48 12.7	74 40 46.4
Milepost 75, road crossing 1,965 feet west of	44 48 25.4	74 39 01.7
Milepost 74, road crossing 2,070 feet east of	44 48 50.0	74 36 57.0
Moira station, road crossing 185 feet west of	44 49 31.8	74 33 24.3
Moira station, about 1,130 feet east of, in rocky pasture about 95 feet south of the center of railway track; a bronze triangulation tablet set in rock outcrop about 1 foot above surface of ground, 70.5 feet from corner of pasture	44 49 34.4	74 33 06.2
Moira station, about 2,100 feet east of, in rocky pasture about 79 feet south of center of railway track, a bronze triangulation tablet set in bowlder about 5 by 2 feet 6 inches above ground. (Tablets 972.65 feet apart)	44 49 37.1	74 32 53.2
Brushton station, road crossing, 245 feet east of	44 49 49.5	74 30 31.2

Geographic positions along Ogdensburg and Lake Champlain Railway from Ogdensburg to Churubusco—Continued.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Milepost 65, road crossing 110 feet west of	44 50 26.3	74 26 58.6
Bangor station, road crossing 100 feet west of	44 51 05.9	74 24 09.9
Milepost 60, road crossing 620 feet west of	44 51 31.4	74 21 34.8
Milepost 58, overhead road crossing 1,580 feet east of	44 51 39.9	74 18 44.6
Malone station, center of	44 50 58.5	74 17 33.8
Malone Junction, crossing of Ogdensburg and Lake Champlain Railway, and Mohawk and Malone Railway	44 51 30.4	74 16 30.0
Malone, Franklin County fair grounds, south meridian monument	44 50 50.4	74 16 38.3
Malone, Franklin County fair grounds, north meridian monument	44 51 00.2	74 16 38.3
Milepost 53, road crossing 2,230 feet west of	44 52 38.6	74 14 42.9
Milepost 51, road crossing 1,160 feet east of	44 53 55.8	74 12 09.0
Burke station, opposite center of	44 54 10.4	74 10 09.8
Milepost 46, road crossing 1,390 feet east of	44 55 12.4	74 06 21.1
Milepost 44, road crossing 1,920 feet west of	44 55 25.8	74 04 44.8
Milepost 43, road crossing 1,150 feet east of	44 55 44.1	74 02 51.9
Milepost 40, road crossing 890 feet west of	44 56 21.0	73 59 48.7
Milepost 39, road crossing 2,695 feet east of	44 56 57.5	73 57 57.5
Churubusco triangulation station, cross on tower of St. Philominus Catholic Church	44 57 15.63	73 55 55.03

Geographic positions along the Adirondack and St. Lawrence Railway (New York Central) from Malone to the International Boundary Line.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Milepost 63, center of bridge over stream 990 feet north of	44 53 24.4	74 17 08.5
Constable station, road crossing 155 feet north of	44 56 00.3	74 17 04.1
Milepost 58, road crossing 2,070 feet north of	44 57 18.5	74 15 21.8
Milepost 56, road crossing 1,060 feet south of	44 58 30.0	74 14 59.3
Iron boundary post No. 728	44 59 43.4	74 15 02.2

Geographic positions along Mohawk and Malone Railway (New York Central) from Malone south to Owls Head Station.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Milepost 2, road crossing 580 feet south of	44 49 24.4	74 15 29.6
Whippleville flag station	44 48 23.6	74 14 39.9
Milepost No. 6	44 46 27.0	74 13 24.6
Chasm Falls flag station, road crossing 675 feet south of	44 45 37.3	74 12 09.6
Owls Head station, road crossing about three-fourths mile north of	44 44 33.2	74 10 32.9
Owls Head triangulation station	44 44 36.81	74 09 35.30

Geographic positions along Rome, Watertown and Ogdensburg Railway from Norwood to Massena Springs.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Milepost 288, road crossing 860 feet south of	44 46 15.8	74 57 33.4
Milepost 290, road crossing 1,640 feet south of	44 47 48.2	74 56 58.0
Plum Brook flag station, road crossing at	44 49 50.8	74 55 19.7
Milepost 294, road crossing 1,540 feet north of	44 51 24.2	74 55 07.5
Milepost 296, road crossing 2,140 feet north of	44 53 06.2	74 54 12.3
Massena Springs station, road crossing 350 feet south of	44 54 53.1	74 53 15.9

Geographic positions along Grand Trunk Railway from Massena Springs to Bombay.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Milepost 94, center of bridge, 330 feet east of	44 55 22.9	74 50 44.1
Milepost 92, road crossing 2,480 feet east of	44 55 34.6	74 47 56.0
Milepost 90, road crossing 1,090 feet east of	44 55 38.7	74 45 48.9
Helena station, New York and Ottawa Railway crossing	44 55 27.1	74 43 01.5
Milepost 85, road crossing 2,045 feet west of	44 55 35.9	74 40 31.5
Milepost 83, road crossing 1,670 feet west of	44 55 44.1	74 38 00.5
Milepost 82, road crossing 245 feet west of	44 55 50.8	74 36 27.9
Bombay station, northwest corner of	44 56 19.2	74 34 19.0
Bombay, church steeple	44 56 22.7	74 33 56.2

Geographic positions along New York and Ottawa Railway from Helena to Moira.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Ironton flag station, road crossing 380 feet north of	44 53 55.9	74 41 06.8
Milepost 62, road crossing 4,125 feet north of	44 53 14.3	74 39 43.2
Milepost 57, road crossing 370 feet north of	44 51 12.9	74 36 14.5
Milepost 56, road crossing one-half mile south of	44 50 15.0	74 34 56.3

Meridian Marks.

BINGHAMTON, BROOME COUNTY.

Location of station: In court-house grounds, Binghamton.

Station mark: A granite post 48 by 8 by 8 inches, set 48 inches in the ground, in the center of top of which is cemented a bronze meridian tablet.

Distant mark: North of station 295.5 feet. A granite post 48 by 8 by 8 inches, set 48 inches in the ground, in center of top of which is cemented a bronze triangulation tablet.

COOPERSTOWN, OTSEGO COUNTY.

Location of station: In the grounds of the Otsego County courthouse, on west side of main building.

Station mark: A marble post 38 by 8 by 6½ inches, set 34 inches in the ground, in the center of top of which is cemented a bronze meridian tablet.

Distant mark: North of station 336 feet. A marble post 38 by 8 by 6½ inches, set 34 inches in the ground. In the center of top is cemented a bronze meridian tablet.

Local referee: E. A. Potter.

DELHI, DELAWARE COUNTY.

Location of station: On grounds of the Delaware County Agricultural Society at Delhi.

Station mark: A marble post 36 by 8 by 8 inches, set 32 inches in the ground, in center of top of which is cemented a bronze meridian tablet.

Distant mark: North of station 491.3 feet. A marble post 26 by 11 by 5 inches, set 23 inches in the ground, and resting on a marble block 8 inches thick. In center of top is cemented a bronze meridian tablet.

GOSHEN, ORANGE COUNTY.

Location of station: In the grounds of the Presbyterian Church of Goshen.

Station mark: A blue sandstone post 36 by 8 by 8 inches, set flush with surface of ground, with a bronze meridian tablet in center of top.

Distant mark: A blue sandstone post 36 by 8 by 8 inches, 357.2 feet north of station mark, set flush with surface of ground. In center of top is a bronze meridian tablet.

HAMILTON, MADISON COUNTY.

Location of station: On Hamilton College campus.

Station mark: A marble post 34 by 6 by 6 inches, set in a concrete column 48 by 24 by 24 inches. In center of top of post is cemented a bronze meridian tablet.

Distant mark: North of station 665.7 feet. True azimuth, 180° 00′ 09″. A marble post 34 by 6 by 6 inches, set in a concrete column 48 by 24 by 24 inches. In center of top of post is cemented a bronze meridian tablet.

MALONE, FRANKLIN COUNTY.

Location of station: On the grounds of the Franklin County Agricultural Association.

Station mark: A marble post 36 by 6 by 6 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze meridian tablet. Post is 2 feet north of fence on inside of race track.

Distant mark: North of station mark 990 feet. A marble post 36 by 6 by 6 inches, set 33 inches in the ground, in the center of top of which is cemented a bronze meridian tablet. Post is 2½ feet south of inside edge of race track and 1 foot south of railing along inside edge of race track.

NORWICH, CHENANGO COUNTY.

Location of station: In City Park, eastward from court-house.

Station mark: A stone post 48 by 12 by 12 inches, with top dressed round, 8 inches in diameter, and set 48 inches in the ground. In the center of top is cemented a copper bolt 4 inches long and 1 inch in diameter.

Distant mark: North of station 185 feet. A stone post 48 by 12 by 12 inches, top dressed round to 8 inches in diameter, set 48 inches in the ground, in the center of top of which is leaded a bronze meridian tablet.

UTICA, ONEIDA COUNTY.

Location of station: On the Oneida-Herkimer county line, which is also the city of Utica boundary line (Turner street), at intersection of West Shore track and Bleeker street.

Station mark: A stone post 48 by 10 by 10 inches, dressed with round top, and set 46 inches in the ground. In the center of top is cemented a bronze meridian tablet on which is stamped "N. 34° 07′ 52″ E." true.

Distant mark: North 34° 07′ 52″, east (true) of station one-third mile. A county line monument 48 by 12 by 12 inches, set 36 inches in the ground. On south side of Broad street east of Turner street.

DELAWARE-MARYLAND.

Primary Traverse.

Seventy-seven geographic positions were determined in the Delaware-Maryland peninsula by primary traverse by George T. Hawkins, topographer, in April and May, 1900. The traverse starts at Hartly triangulation station of the United States Coast and Geodetic Survey and follows the Philadelphia, Wilmington and Baltimore Railroad to Easton, thence along the Baltimore, Chesapeake and Atlantic Railroad to Berlin, thence northward along the former road to Lewes, Del., connecting with the light-house at Cape Henlopen, a triangulation station of the United States Coast and Geodetic Survey.

A line also runs along the New York, Philadelphia and Norfolk Railroad from Salisbury to Crisfield, connecting with the light-house at the latter place located by the United States Coast and Geodetic Survey. A spur line runs along the Philadelphia, Wilmington and Baltimore Railroad southward from Berlin to Franklin City, Virginia.

Geographic positions along the Philadelphia, Wilmington and Baltimore Railroad.

Stations.	Latitude.	Longitude.
DELAWARE.		
	° ′ ″	° ′ ″
Hartly triangulation station, United States Coast and Geodetic Survey	39 10 48.86	75 40 17.8
Hartly railroad station	39 09 59.9	75 42 37.8
Slaughter station	39 09 30.5	75 42 57.7
Maryland-Delaware State line crossing	39 06 50.9	75 44 44.5
MARYLAND.		
Marydel station	39 06 45.3	75 44 47.3
Henderson station	39 04 31.2	75 45 56.1
Goldsboro station	39 02 07.4	75 47 09.8
Road crossing at milepost 22	39 00 08.3	75 48 10.8
Greensboro station	38 58 39.0	75 49 01.9
Ridgely station	38 56 50.1	75 53 10.7
Queen Anne station	38 55 13.6	75 57 21.7
Cordova	38 52 32.0	75 59 45.3
Chapel station	38 50 25.9	76 01 31.0
Road crossing at station	38 48 37.8	76 03 01.6
Easton, Philadelphia, Wilmington and Baltimore Railroad station	38 46 33.4	76 04 07.4
Easton, crossing of railroads southeast of	38 45 59.8	76 04 08.2

Geographic positions along the Baltimore, Chesapeake and Atlantic Railroad.

Stations.	Latitude.	Longitude.
MARYLAND.	° ′ ″	° ′ ″
Turner station	38 44 44.5	76 00 38.5
Bethlehem station	38 44 40.5	75 56 47.4
Preston station	38 42 36.8	75 54 42.0
Ellwood	38 41 11.9	75 53 16.2
Hurlock	38 38 09.1	75 51 42.2
Hurlock, crossing of railways at	38 38 08.3	75 51 42.0
Ennals station, crossing at	38 36 02.6	75 50 49.7
Rhodesdale station	38 34 38.1	75 50 14.1
Reedsgrove station	38 32 01.1	75 49 39.4
Vienna station	38 29 06.8	75 49 22.5
Mardela Springs station	38 27 45.7	75 45 27.6
Crossing 1,500 feet west of station	38 26 33.6	75 43 40.0
Hebron station	38 25 08.9	75 41 22.7
Rockawalking station	38 24 04.8	75 39 38.8
Road crossing 500 feet east of station	38 22 57.1	75 37 50.9
Salisbury, Baltimore, Chesapeake and Atlantic station	38 22 21.4	75 35 47.6
Road crossing at station	38 22 41.8	75 33 17.2
Parsonsburg station	38 23 16.7	75 28 04.4
Pittsville station	38 23 43.4	75 24 48.2
Road crossing at station	38 23 48.1	75 22 05.4
Willards station	38 23 43.0	75 20 59.2
Whaleysville station	38 23 42.2	75 18 08.4
St. Martin station	38 22 23.1	75 14 55.4
Berlin, crossing of railways at	38 19 42.2	75 13 18.4

Geographic positions along the Philadelphia, Wilmington and Baltimore Railway.

Stations.	Latitude.	Longitude.
MARYLAND.	° ′ ″	° ′ ″
Road crossing at station north of Berlin	38 22 21.5	75 12 46.1
Showell station	38 23 58.2	75 12 57.4
Bishop station	38 25 40.6	75 13 18.5
Maryland-Delaware State line near Selbyville	38 27 04.7	75 13 39.4
DELAWARE.		
Selbyville station	38 27 27.8	75 13 41.9
Frankford station	38 31 03.3	75 14 11.8
Dagsboro station	38 32 50.3	75 14 57.8
Millsboro station	38 35 17.9	75 17 33.8
Stockley station	38 38 28.7	75 20 26.7
Georgetown, south end of Y	38 41 20.2	75 22 42.3
Road crossing at west end of siding	38 42 07.3	75 20 37.8
Broadkill station	38 43 15.0	75 17 05.5
Cool Spring station (Harbeson post-office)	38 43 56.6	75 14 54.9
Nassau station	38 45 06.7	75 11 14.3
Lewes station	38 46 02.8	75 08 29.4
Cape Henlopen light-house, United States Coast and Geodetic Survey triangulation station	38 46 41.7	75 05 02.9

Geographic positions along the Philadelphia, Wilmington and Baltimore Railroad between Berlin, Md., and Franklin City, Va.

Stations.	Latitude.	Longitude.
MARYLAND.	° ′ ″	° ′ ″
Ironshire station	38 17 38.8	75 15 06.4
Crossing 470 feet north of head block	38 16 13.3	75 16 27.8
Newark station	38 15 06.6	75 17 33.1
Wesley station	38 12 35.3	75 20 43.9
Snow Hill station	38 10 38.7	75 23 06.9
Scarboro station	38 08 00.3	75 23 43.3
Girdletree station	38 05 42.7	75 24 09.9
Hursley station	38 03 18.1	75 24 40.9
Maryland-Virginia State line	38 00 51.6	75 23 20.7
VIRGINIA.		
Franklin City station	38 00 24.1	75 22 58.4

Geographic positions along the New York, Philadelphia and Norfolk Railroad between Salisbury and Crisfield, Md.

Stations.	Latitude.	Longitude.
MARYLAND.	° ′ ″	° ′ ″
Maryland-Delaware State line at Delmar	38 27 22.5	75 34 42.7
Salisbury, crossing at north end of siding 3 miles north of	38 24 26.6	75 35 02.7
Fruitland station	38 19 18.2	75 37 10.3
Eden station	38 16 53.9	75 39 00.5
Loretto station	38 14 52.1	75 40 33.4
Princess Anne station	38 12 01.9	75 41 26.7
Kings Creek, junction of railways	38 09 53.8	75 41 20.6
Kings Creek station (Peninsula Junction post-office)	38 09 50.8	75 41 20.6
Westover station	38 07 31.5	75 42 20.5
Kingston station	38 04 27.9	75 43 40.9
Marion station	38 02 20.6	75 46 19.0
Hopewell station	38 00 28.8	75 49 07.0
Crossing 170 feet east of switch block	37 59 21.2	75 50 48.6
Crisfield light-house, United States Coast and Geodetic Survey triangulation station	37 57 59.5	75 52 39.75

PENNSYLVANIA.

Primary Traverse.

Primary traverse for the control of the Westchester 15-minute quadrangle in March, 1901.

The following geographic positions were determined by Mr. Sledge Tatum, topographer, by primary traverse which begins at Granogue, Del., a triangulation station of the United States Coast and Geodetic Survey, and runs north to Chadds Ford, Pa., on the Wilmington and Northern Railroad; thence north via highways to Cheyney station, on Westchester Railroad; thence north on same railroad to Greenhill station; thence west via highways to Whiteland station, on Pennsylvania Railroad; thence west on Pennsylvania Railroad to Thorndale; thence south via highways, touching Embreeville and Unionville to Kennett Square, Pa., on Philadelphia, Wilmington and Baltimore Railroad; thence east to Chadds Ford.

Geographic positions along Wilmington and Northern Railroad.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Granogue triangulation station	39 49 47.5	75 34 50.8
Delaware-Pennsylvania State line	39 50 18.4	75 35 07.4
Cossart station	39 50 48.1	75 35 46.0
Brookfield station	39 51 11.8	75 35 48.4
Chadds Ford Junction	39 52 08.0	75 35 46.4

Geographic positions along Westchester Railroad.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Cheyney station	39 55 44.2	75 31 23.6
Westtown station	39 55 55.6	75 32 58.6
Westchester, northwest end car shed	39 57 41.3	75 36 03.0
Fern Hill station	39 58 44.4	75 35 29.4
Green Hill station	39 59 42.3	75 36 04.8

Geographic positions along Pennsylvania Railroad.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Whiteland, road crossing at	40 01 09.3	75 37 22.9
Bradford Hill station	40 00 22.1	75 39 46.2
Woodbine station, road crossing at	40 00 18.4	75 41 10.7
Downingtown, road crossing 600 feet west of	40 00 10.5	75 42 08.0
Gallaghersville station	39 59 50.3	75 41 08.4
Thorndale, road crossing at	39 59 38.5	75 45 21.0

Geographic positions along highways from Thorndale to Kennett Square.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Embreeville station	39 55 48.9	75 44 05.4
Unionville, crossing of streets	39 53 43.2	75 44 05.7

Geographic positions along Philadelphia, Wilmington and Baltimore Railroad.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Kennett Square station	39 50 32.2	75 42 34.4
Rosedale station	39 50 51.4	75 39 46.8
Fairville	39 51 11.2	75 38 32.4
Chadds Ford Junction	39 52 08.0	75 35 46.4
Brandywine Summit station	39 52 26.2	75 32 41.5
Concordville, crossing 600 feet west of	39 52 38.5	75 30 50.4
Markham station	39 53 26.3	75 30 22.2

Triangulation Stations.

The descriptions and positions published herewith, resulting from the field work of 1899 and 1900, executed under the supervision of Mr. S. S. Gannett, topographer, in Franklin, Fulton, Bedford, Blair, Huntingdon, and Cambria counties, were established by Mr. Sledge Tatum, topographer, in 1899, and by Mr. A. H. Thompson, geographer, in 1900.

Stations in the southwestern portion of the State in Fayette, Greene, Washington, Westmoreland, Allegheny, Beaver, Indiana, Armstrong, and Clarion counties, result from the work of Messrs. A. H. Thompson, geographer; S. S. Gannett, Sledge Tatum, topographers; D. H. Baldwin and W. R. Harper, assistant topographers, and E. L. McNair, field assistant. All positions are based upon Maryland Heights and Sugarloaf stations of the United States Coast and Geodetic Survey, and on "United States Standard Datum." Distances were checked by a base line, measured by Mr. S. S. Gannett, on the main line of the Pennsylvania railroad passing through Hillside, Westmoreland County, and check azimuths were observed at three primary stations, namely, Krepp, Dawson, and Hillside North Base.

Triangulation for control of the Carlisle and Gettysburg sheets was extended westward from Round Top and Pulpit Rock of the United States Coast and Geodetic Survey by Mr. S. S. Gannett in August and September, 1900.

ROUND TOP, YORK COUNTY.

A station of the United States Coast and Geodetic Survey in Warrington Township, 8 miles east of Dillsburg. The summit is timbered and can be reached by trail from the house of Harrison Nesbit, 1 mile distant.

Theodolite elevated 30 feet.

Station mark: A sandstone post 18 by 6 by 6 inches, set 15 inches in the ground and resting on a flat rock having cross lines cut on its upper surface.

[Latitude 40° 06′ 13.24″. Longitude 76° 55′ 34.14″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pulpit Rock	3 56 07.80	183 55 16.94	4.4378302
Fickle Hill	73 21 43.73	253 13 17.53	4.2889163

PULPIT ROCK.

On county line between York and Adams counties.

A station of the United States Coast and Geodetic Survey, 5 miles by road north of Hanover and about 3 miles east of Abbotstown. The station is on a rocky backbone of the heavily timbered summit of the Pigeon Hills.

Theodolite elevated 35 feet.

Station mark: A stone post 20 by 6 by 6 inches, set 18 inches in the ground and resting on a flat rock.

[Latitude 39° 51′ 26.77″. Longitude 76° 56′ 53.27″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gettysburg, Round Top	72 30 33.80	252 19 22.35	4.4175998
Fickle Hill	142 24 17.92	322 16 43.84	4.4388914
Round Top	183 55 16.94	3 56 07.80	4.4378302

FICKLE HILL, ADAMS COUNTY.

On a partly cleared flat ridge near the northern extremity of the county, 2 miles north of Latimer post-office. The station is 30 feet northeast of outcropping ledge on highest part of ridge on land owned by W. A. Bream.

Theodolite elevated 30 feet.

Station mark: A stone post 36 by 10 by 10 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 03′ 11.94″. Longitude 77° 08′ 40.37″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gettysburg, Round Top	15 19 22.10	195 15 43.03	4.4876976
Round Top	253 13 17.53	73 21 43.73	4.2889163
Pulpit Rock	322 16 43.84	142 24 17.92	4.4388914

GETTYSBURG, ROUND TOP, ADAMS COUNTY.

The noted round knob, 3 miles south of Gettysburg.

Theodolite mounted on upper floor of the iron observation tower, about 70 feet above ground.

Station mark: Center of stone foundation of tower.

[Latitude 39° 47′ 10.54″. Longitude 77° 14′ 21.74″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Fickle Hill	195 15 43.03	15 19 22.10	4.4876976
Pulpit Rock	252 19 22.35	72 30 33.80	4.4175998

ALTO, FRANKLIN COUNTY.

(Not occupied.)

About 9½ miles southeast of Chambersburg and 1 mile east of Mont Alto, on mountain locally known by that name.

Signal: A wooden observation tower in Mont Alto Park.

[Latitude 39° 50′ 04.06″. Longitude 77° 32′ 08.72″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Fairview	62 06 34.6	241 49 55.8	4.6246864
Parnell	108 11 58.4	287 59 23.8	4.4687745
Chambersburg	136 56 56.7	316 52 07.6	4.1954468

CHAMBERSBURG, FRANKLIN COUNTY.

The balcony of the clock tower on the county court-house at Chambersburg was occupied and the angles reduced to center of tower.

Station mark: Center of clock tower.

[Latitude 39° 56′ 15.41″. Longitude 77° 39′ 39.62″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Parnell	82 25 31.4	262 17 45.3	4.2405209
Quirauk	334 33 43.9	154 39 25.8	4.4715130
Alto	316 52 07.6	136 56 56.7	4.1954468

PARNELL, FRANKLIN COUNTY.

On mountain locally known by same name, about 9 miles west of Chambersburg and 3 miles east of Fort London.

Theodolite elevated 24 feet on stump of a tree; sight lines cut through timber to other stations.

Station mark: A bronze tablet marked "U. S. Geological Survey—Pennsylvania," cemented in solid rock.

[Latitude 39° 55′ 00.42″. Longitude 77° 51′ 45.82″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Fairview	17 36 22.3	197 32 15.8	4.4822860
Cove	44 49 11.6	224 41 37.6	4.3790001
Pike	88 07 15.8	268 03 34.2	3.9142524
Chambersburg	262 17 45.3	82 25 31.4	4.2405209
Alto	287 59 25.8	108 11 58.4	4.4687745
Quirauk	309 04 53.8	129 18 20.6	4.5874493
Martin	340 38 14.6	160 42 52.2	4.4941249

PIKE, ON LINE BETWEEN FRANKLIN AND FULTON COUNTIES.

About 5 miles air-line distance northwest of Mercersburg and 3 miles east of McConnellsburg, on Cove Mountain, 1,000 feet south of Chambersburg and Bedford pike.

Theodolite elevated 16 feet on stump of tree; sight lines cut through timber to other stations.

Station mark: A copper bolt cemented in solid rock.

[Latitude 39° 54′ 51.55″. Longitude 77° 57′ 31.23″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Cove	27 21 16.2	207 17 23.4	4.2746459
Ray	68 27 08.0	248 13 43.0	4.5068009
Smith	123 53 29.4	303 46 16.2	4.2849006
Parnell	268 03 34.2	88 07 15.8	3.9142524

COVE, ON LINE BETWEEN FRANKLIN AND FULTON COUNTIES.

On mountain known by that name, about 4 miles north of Pennsylvania-Maryland State line, and 2 miles east of Hancock and McConnellsburg road, on highest point of mountain.

Theodolite elevated 14 feet on stump of tree, with sight lines cut through timber to other stations.

Station mark: A bronze tablet marked "U. S. Geological Survey, Pennsylvania" cemented in solid rock.

[Latitude 39° 45′ 49.37″. Longitude 78° 03′ 34.56″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Ray	102 58 51.6	282 49 20.4	4.3382797
Smith	164 57 17.7	344 53 58.2	4.4537546
Pike	207 17 23.4	27 21 16.2	4.2746459
Parnell	224 41 37.6	44 49 11.6	4.3790001
Fairview	327 08 38.8	147 12 05.6	4.1528312

SMITH, FULTON COUNTY.

On land owned by George Smith, of Sideling Hill, about 2 miles west of Saluvia and one-half mile south of Chambersburg and Bedford pike. Sight lines were cut through timber to other stations.

Station mark: A stone post, 48 by 10 by 10 inches, set flush with surface of ground, in the center of top which is cemented a bronze tablet marked "U. S. Geological Survey, Pennsylvania."

[Latitude 40° 00′ 39.42″. Longitude 78° 08′ 45.70″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Ray	31 30 03.8	211 23 50.7	4.4228184
Everett	80 33 28.2	260 22 54.7	4.3749415
Government	109 19 39.0	289 13 32.6	4.1555140
Tussey	142 16 53.0	322 09 26.6	4.4280288
Pike	303 46 16.2	123 53 29.4	4.2849006
Cove	344 53 58.2	164 57 17.7	4.4537546

HICKS, BLAIR, AND HUNTINGDON COUNTIES.

Situated on the crest of Tussey Mountain, about one-half mile north of point at which the Williamsburg and Marklesburg pike crosses the mountain.

Station mark: A bronze triangulation tablet cemented in solid rock.

[Latitude 40° 25′ 19.33″. Longitude 78° 10′ 05.10″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Beavertown	29 39 23.5	209 37 46.2	3.8550653
Point View	143 14 11.6	323 11 37.8	3.9709241

TERRACE (2), HUNTINGDON COUNTY.

(Not occupied.)

Situated on a high ridge known locally as Terrace Mountain, about 1 mile south of the Entriken bridge over the Juniata River and one-fourth mile south of the Entriken and Trough Creek road.

Station mark: A bronze triangulation tablet set in solid rock.

[Latitude 40° 17′ 49.66″. Longitude 78° 10′ 14.31″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Lytle	86 55 39.6	266 52 10.0	3.8846175
Beavertown	156 29 07.8	336 27 36.6	3.9210568

BEAVERTOWN, ON LINE BETWEEN BLAIR AND HUNTINGDON COUNTIES.

On the crest of Tussey Mountain, about three-fourths mile south of point where the Beavertown and Marklesburg pike crosses the summit. Outlook good in all directions where trees are cut, except along the axis of the mountain.

Station mark: A bronze triangulation tablet cemented in solid rock.

[Latitude 40° 21′ 57.51″. Longitude 78° 12′ 35.31″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Lytle	28 13 34.4	208 11 35.9	3.9612280
Rattlesnake	61 01 14.4	240 52 11.6	4.3552251
Duncan	83 05 00.4	262 59 21.0	4.0955332
Point View	171 27 30.0	351 26 33.3	4.1420604
Hicks	209 37 46.2	29 39 23.5	3.8550653
Terrace (2)	336 27 36.6	156 29 07.8	3.9210568

POINT VIEW, BLAIR COUNTY.

Situated about 3 miles west of Williamsburg and one-half mile north of Point View railroad station, on the southern end of a high rocky ridge on the north bank of the Frankstown Branch of the Juniata River. Outlook good to southeast, southwest, and northwest.

Station mark: A bronze triangulation tablet cemented in solid rock, above which was piled a cairn of rocks 5 feet high.

[Latitude 40° 29′ 22.17″. Longitude 78° 14′ 02.78″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Lytle	5 55 28.3	185 54 26.3	4.3402766
Hicks	323 11 37.3	143 14 11.6	3.9709241
Beavertown	351 26 33.3	171 27 30.0	4.1420604

LYTLE, BLAIR, AND HUNTINGDON COUNTIES.

Situated on a high, rocky, timbered ridge on Tussey Mountain, about one-half mile south of point at which the Martinsburg and Cove Creek pike crosses the mountain. Outlook good where trees have been cut away except directly along the axis of mountain.

Station mark: A bronze triangulation tablet cemented in solid rock.

[Latitude 40° 17′ 36.21″. Longitude 78° 15′ 38.44″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Rattlesnake	79 17 50.6	259 10 46.7	4.1977839
Duncan	129 09 18.8	309 05 38.2	4.0161348
Point View	185 54 26.3	5 55 28.3	4.3402766
Beavertown	208 11 35.9	28 13 34.4	3.9612280
Terrace (2)	266 52 10.0	86 55 39.6	3.8846175

GOVERNMENT, BEDFORD COUNTY.

On public land, on timbered mountain about 7 miles northeast of Everett and 3 miles east of Tatesville, and one-half mile north of "Horseshoe" bend in Juniata River.

Station mark: Lone hickory signal tree.

[Latitude 40° 03′ 12.55″. Longitude 78° 18′ 15.24″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Ray	0 35 52.3	180 35 44.6	4.4363099
Everett	48 48 27.0	228 43 59.5	4.1180018
Dunning	125 25 37.3	305 21 47.6	4.0157449
Tussey	169 55 55.6	349 54 36.0	4.2230180
Smith	289 13 32.6	109 19 39.0	4.1555140

RAY, ON LINE BETWEEN FULTON AND BEDFORD COUNTIES.

On Ray Mountain, about 5 miles north of Pennsylvania-Maryland State line, and 2 miles west of Amaranth, Pa., on high knob in cleared field.

Station mark: A stone post, 42 by 8 by 8 inches, set flush with surface of ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey-Pennsylvania."

[Latitude 39° 48′ 27.13″. Longitude 78° 18′ 27.22″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Everett	152 48 22.5	332 44 03.3	4.3219063
Government	180 35 44.6	0 35 52.3	4.4363099
Smith	211 23 50.7	31 30 03.8	4.4228184
Pike	248 13 43.0	68 27 08.0	4.5068009
Cove	282 49 20.4	102 58 51.6	4.3382797

TUSSEY, BEDFORD COUNTY.

On mountain locally known by that name about 4 miles northeast of Loysburg, on high point of ridge, in scrubby timber, with lines of sight cut out to other stations.

Station mark: A bronze tablet marked "U. S. Geological Survey-Pennsylvania" cemented in solid rock.

[Latitude 40° 12′ 06.01″. Longitude 78° 20′ 18.76″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters..*
Dunning	27 52 15.0	207 49 44.6	4.0724843
Rattlesnake	129 14 31.7	309 10 29.2	4.0589373
Hartman	170 12 18.8	350 10 39.2	4.3294423
Duncan	175 06 22.4	355 05 43.2	4.2251748
Smith	322 09 26.6	142 16 53.0	4.4280288
Government	349 54 36.0	169 55 55.6	4.2230180

BRUSH MOUNTAIN, BLAIR COUNTY.

Situated about 5 miles nearly north from Hollidaysburg on the highest part of the southern end of Brush Mountain. Sight lines cut through timber toward other stations.

Station mark: A bronze triangulation tablet cemented in a large rock and buried in the ground, above which is a pile of rocks 5 feet high.

[Latitude 40° 29′ 11.34″. Longitude 78° 21′ 08.93″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Rattlesnake	17 29 43.6	197 26 12.9	4.4076197
Hartman	13 02 33.5	193 01 26.1	4.0360067
Foot of Plane Eight	62 43 14.7	242 37 01.0	4.1841092
Tunnel Hill	88 07 39.0	268 00 09.1	4.2130517
Wopsononock	140 20 48.0	320 17 22.4	4.0670251

DUNCAN, BLAIR COUNTY.

Situated 3 miles northeast of Martinsburg on the highest summit of Locke or Loop Mountain. The summit is flat and long lines of sight were cut toward other stations.

Station mark: A rough stone 3 feet long set flush with surface of ground with a bronze triangulation tablet cemented in its top.

[Latitude 40° 21′ 08.53″. Longitude 78° 21′ 19.47″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Dunning	8 32 57.6	188 31 06.2	4.4391035
Rattlesnake	38 04 55.3	218 01 31.7	4.0811989
Hartman	152 56 07.1	332 54 27.5	3.6845025
Lytle	309 05 38.2	129 09 18.8	4.0161348
Tussey	355 05 43.2	175 06 22.4	4.2251748
Beavertown	262 59 21.0	83 05 00.4	4.0955332

HARTMAN, BLAIR COUNTY.

Situated on that part of Locke or Loop Mountain locally known as Hartmans Lookout. It is just north of Dry Gap and about 3 miles east of Hollidaysburg. Outlook good in all directions except northeast.

Station mark: A bronze triangulation tablet cemented in solid rock.

[Latitude 40° 23′ 28.18″. Longitude 78° 22′ 52.88″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Rattlesnake	20 45 13.1	200 42 49.8	4.1689721
Foot of Plane Eight	107 49 10.7	287 44 04.6	4.0678265
Wopsononock	165 39 47.0	345 37 29.0	4.3052551
Altoona	176 59 36.4	356 59 14.0	4.1888990
Brush Mountain	193 01 26.1	13 02 33.5	4.0360067
Duncan	332 54 27.5	152 56 07.1	3.6845025
Tussey	350 10 39.2	170 12 18.8	4.3294423

ALTOONA, BLAIR COUNTY.

An astronomic station of the United States Coast and Geodetic Survey situated on a low hill about one-eighth mile east of Juniata Station on the Pittsburg, Johnstown, Ebensburg and Eastern Railway, on land owned by the Pennsylvania Railroad Company, within the city limits of Altoona.

Station mark: A block of sandstone 5 feet long, 34 inches wide, and 20 inches thick, standing 30 inches above ground and resting on a concrete bed 16 inches thick. In the top is a copper bolt 3½ inches long and 1 inch in diameter.

[Latitude 40° 31′ 47.24″. Longitude 78° 23′ 23.88″.]

DUNNING, BEDFORD COUNTY.

On mountain locally known by that name, about 10 miles north of Mount Dallas and 4 miles south of New Enterprise, on timbered land owned by William Over.

Station mark: A bronze tablet, marked "U. S. Geological Survey—Pennsylvania," cemented in solid rock.

[Latitude 40° 00′ 27.28″. Longitude 78° 24′ 11.99″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Rattlesnake	169 14 46.9	349 13 15.1	4.2553913
Duncan	188 31 06.2	8 32 57.6	4.4391035
Tussey	207 49 44.6	27 52 15.0	4.0724843
Government	305 21 47.6	125 25 37.3	4.0157449
Everett	5 29 26.9	185 28 48.7	4.1679624

EVERETT, BEDFORD COUNTY.

On high summit of Tussey Mountain, about 3 miles south of Everett.

Station mark: A bronze tablet, marked "U. S. Geological Survey—Pennsylvania," cemented in solid rock.

[Latitude 39° 58′ 32.14″. Longitude 78° 25′ 11.35″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Dunning	185 28 48.7	5 29 26.9	4.1679624
Government	228 43 59.5	48 48 27.0	4.1180018
Smith	260 22 54.7	80 33 28.2	4.3749415
Ray	332 44 03.3	152 48 22.5	4.3219063

WOPSONONOCK, BLAIR COUNTY.

Situated about 5 miles west of north of Altoona on the end of a salient of the Allegheny Mountains, reached by a railroad from Juniata.

Station mark: Center of a building known as the Pavilion or Lookout. No permanent mark.

[Latitude 40° 34′ 02.48″. Longitude 78° 26′ 25.47″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Rattlesnake	0 21 11.3	180 21 05.7	4.5233043
Foot of Plane Eight	20 56 00.5	200 53 12.0	4.2335884
Tunnel Hill	42 56 58.4	222 52 53.8	4.1144504
Ebensburg	69 03 56.0	248 52 50.5	4.4120416
Carrolltown	99 51 29.9	279 41 00.9	4.3631044
Brush Mountain	320 17 22.4	140 20 48.0	4.0670251
Hartman	345 37 29.0	165 39 47.0	4.3052551

RATTLESNAKE, ON LINE BETWEEN BEDFORD AND BLAIR COUNTIES.

On high rocky point on Dunning Mountain, about one-half mile east of Claysburg and 2 miles south of Ore Hill; one-half mile south of road from Ore Hill to Claysburg.

Station mark: A bronze tablet, marked "U. S. Geological Survey—Pennsylvania," cemented in solid rock.

[Latitude 40° 16′ 00.75″. Longitude 78° 26′ 34.17″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Foot of Plane Eight	161 12 12.7	341 09 30.3	4.2636520
Wopsononock	180 21 05.7	360 21 11.3	4.5233043
Brush Mountain	197 26 12.9	17 29 43.6	4.4076197
Hartman	200 42 49.8	20 45 13.1	4.1689721
Duncan	218 01 31.7	38 04 55.3	4.0811989
Beavertown	240 52 11.6	61 01 14.4	4.3552251
Lytle	259 10 46.7	79 17 50.6	4.1977839
Tussey	309 10 29.2	129 14 31.7	4.0589373
Dunning	349 13 15.1	169 14 46.9	4.2553913

FOOT OF PLANE EIGHT, BLAIR COUNTY.

Situated about 8 miles south of west from Hollidaysburg, on the north end of a wooded mountain locally known as "Foot of 8." Outlook to west not good.

Station mark: A bronze triangulation tablet set in foot of signal tree.

[Latitude 40° 25′ 23.90″. Longitude 78° 30′ 44.98″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Tunnel Hill	156 54 52.0	336 53 36.1	3.8467742
Wopsononock	200 53 12.0	20 56 00.5	4.2335884
Brush Mountain	242 37 01.0	62 43 14.7	4.1841092
Hartman	287 44 04.6	107 49 10.7	4.0678265
Rattlesnake	341 09 30.3	161 12 12.7	4.2636520

TUNNEL HILL, CAMBRIA COUNTY.

Situated on the highest point of Tunnel Hill, in Tunnel Hill Borough, ½-mile from Gallitzen railroad station.

Station mark: A stone post 40 by 6 by 6 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 40° 28′ 53.46″. Longitude 78° 32′ 41.96″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Ebensburg	91 03 21.1	270 56 20.7	4.1834198
Thomas Ridge	111 12 17.8	291 03 58.1	4.2881836
Carrolltown	134 07 14.1	314 00 50.3	4.2863416
Wopsononock	222 52 53.8	42 56 58.4	4.1144504
Brush Mountain	268 00 09.1	88 07 39.0	4.2130517
Foot of Plane Eight	336 53 36.1	156 54 52.0	3.8467742

CARROLLTOWN, CAMBRIA COUNTY.

(Not occupied.)

Spire of Catholic Church in Carrolltown.

Station mark: Center of spire.

[Latitude 40° 36′ 09.43″. Longitude 78° 42′ 32.31″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Ebensburg	5 50 15.6	185 49 38.4	4.1222362
Wopsononock	279 41 00.9	99 51 29.9	4.3631044
Tunnel Hill	314 00 50.3	134 07 14.1	4.2863416

EBENSBURG, CAMBRIA COUNTY.

Center of cupola of court-house in Ebensburg.

Station mark: Center of cupola.

[Latitude 40° 29′ 02.07″. Longitude 78° 43′ 29.55″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Thomas Ridge	156 58 16.9	336 56 57.9	3.8644861
Carrolltown	185 49 38.4	5 50 15.6	4.1222362
Wopsononock	248 52 50.5	69 03 56.0	4.4120416
Tunnel Hill	270 56 20.7	91 03 21.1	4.1834198

M'COY, INDIANA COUNTY.

About 1 mile southeast of Taylorville post-office, on a bare round-top hill owned by James McCoy.

Station mark: A stone post 42 by 6 by 6 inches, set 38 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 41′ 59.77″. Longitude 78° 58′ 08.22″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Strong	32 54 04.0	212 50 44.6	4.1223126
Coleman	68 46 47.2	248 38 22.5	4.2905687
Kunkle	92 39 25.9	272 30 14.2	4.2983645
Rowland	129 59 46.3	309 51 01.2	4.3907798
Palmer	176 52 15.4	356 51 59.4	4.0225275
Nolo	357 23 52.1	177 24 09.6	4.1440697

PALMER, INDIANA COUNTY.

About 2½ miles south of Rochester Mills post-office, in Grant Township, on a very high partly cleared ridge, on land owned by Mr. Palmer.

Station mark: A stone post 36 by 6 by 6 inches, set 33 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

Reference marks: Stones set 1 foot below surface of ground with cross on top, in line with stations Rowland and McCoy; distant 10 feet from station.

[Latitude 40° 47′ 40.71″. Longitude 78° 58′ 32.74″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Kunkle	63 32 19.9	243 23 23.7	4.3331827
Rowland	106 08 44.8	286 00 15.2	4.2790843
McCoy	356 51 59.4	176 52 15.4	4.0225275

NOLO, INDIANA COUNTY.

About one-fourth mile north of Nolo post-office, on land owned by Mr. McCaffery, on high ground, but not the highest point.

Station mark: A stone post 42 by 6 by 6 inches, set 38 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

Reference marks: Stones set 1 foot below surface of ground with cross on top, and set on line with Evans and McCoy; distant 10 feet from station.

[Latitude 40° 34′ 28.50″. Longitude 78° 57′ 41.33″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Evans	87 28 07.9	267 23 18.4	4.0203741
Warner	99 44 21.0	279 34 16.2	4.3458154
Strong	109 37 38.4	289 34 01.7	3.9198276
McCoy	177 24 09.6	357 23 52.1	4.1440697

STRONG, INDIANA COUNTY.

In Cherry Hill Township, about 2 miles southwest of Greenville village, on the highest hill in the immediate vicinity, on land owned by H. B. Strong. There is a lone tree on the southwest part of hill.

Station mark: A stone post 36 by 6 by 6 inches, set 32 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 35′ 58.92″. Longitude 79° 03′ 14.39″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Warner	93 50 53.6	273 44 25.4	4.1478120
Coleman	110 12 12.0	290 07 07.2	4.0691774
Kunkle	133 32 00.8	313 26 09.2	4.2424222
McCoy	212 50 44.6	32 54 04.0	4.1223126
Nolo	289 34 01.7	109 37 38.4	3.9198276

EVANS, INDIANA COUNTY.

In Brush Valley Township, on land owned by John Evans, on highest part of hill cleared of timber with the exception of two small chestnut trees.

Station mark: A stone post 36 by 8 by 8 inches, set 33 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U: S. Geological Survey—Pennsylvania."

[Latitude 40° 34′ 13.27″. Longitude 79° 05′ 06.43″.]

To station—	Azimuth.	Back azimuth.	Log. distance
	° ′ ″	° ′ ″	*Meters.*
Widow	26 48 12.1	206 45 05.2	4.1773173
Watt	101 41 54.2	281 34 19.5	4.2248181
Warner	110 18 57.3	290 08 42.1	4.0841382
Indiana Normal School Cupola	129 57 46.9	309 54 54.2	3.9106425
Coleman	131 06 21.9	311 02 30.0	4.0457724
Nolo	267 23 18.4	87 28 07.9	4.0203741

INDIANA NORMAL SCHOOL, INDIANA COUNTY.

(Not occupied.)

Station mark: Cupola of Normal School Building.

[Latitude 40° 37′ 02.69″. Longitude 79° 09′ 31.86″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Warner	78 37 54.9	258 35 32.4	3.7203033
Evans	309 54 54.2	129 57 46.9	3.9106425

WIDOW, INDIANA COUNTY.

In Black Lick Township, about 6 miles east of Blairsville, on the Blairsville and Ebensburg pike. It is on a bare hill about 20 rods south of the road, on land owned by the heirs of J. W. Thompson.

Station mark: A stone post 48 by 6 by 6 inches, set 44 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 26′ 57.89″. Longitude 79° 09′ 54.27″.

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ″	° ′ ″	*Meters.*
Jellison	69 46 07.1	249 39 35.6	4.1810596
Kelly	93 39 09.9	273 35 33.0	3.8972129
Tabernacle	113 29 15.9	293 21 31.4	4.2639820
Watt	150 07 07.1	330 02 40.0	4.2877768
Warner	165 18 07.7	345 15 60.0	4.2604466
Evans	206 45 05.2	26 48 12.1	4.1773173

√ COLEMAN, INDIANA COUNTY.

In White Township, about 2 miles west of Indiana, on land owned by D. Coleman.

Station mark: A stone post 42 by 6 by 6 inches, set 38 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

Reference marks: Stone sunk 2 feet below the surface of ground in direction of Kunkle station; distant 10.2 feet to cross on stone. Stone sunk 18 inches below surface of ground in direction of Warner station; distant 12.3 feet to cross on stone.

[Latitude 40° 38′ 09.95″. Longitude 79° 11′ 02.71″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Warner	44 04 52.9	224 03 29.4	3.6365727
Watt	64 05 54.9	244 02 11.8	3.9520747
Broadview	122 32 38.9	302 28 27.8	4.0307069
Kunkle	168 08 51.4	348 08 04.9	3.9115917
McCoy	248 38 22.5	68 46 47.2	4.2905687
Strong	290 07 07.2	110 12 12.0	4.0691774
Evans	311 02 30.0	131 06 21.9	4.0457724

ROWLAND, INDIANA COUNTY.

On a high hill on land owned by W. S. Rowland. About 4 miles north of Plumville, in North Mahoning Township, and near the line between North and South Mahoning Townships.

Station mark: A stone post 40 by 6 by 6 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 30° 50′ 31.39″. Longitude 79° 11′ 32.36″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Kunkle	3 45 50.3	183 45 23.0	4.1737351
Graham	67 20 45.1	247 12 03.4	4.3072670
Clever	117 12 06.0	297 06 56.5	4.0951985
Palmer	286 00 15.2	106 08 44.8	4.2790843
McCoy	309 51 01.2	129 59 46.3	4.3907798

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KUNKLE, INDIANA COUNTY.

On land owned by Philip Kunkle; about 3 miles north of Creekside post-office, near western end of a high ridge having scattering trees on the eastern end.

Station mark: A stone post 42 by 6 by 6 inches, set 36 inches in the ground on solid rock, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 42′ 28.78″. Longitude 79° 12′ 14.09″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Warner	6 51 34.4	186 50 57.4	4.0482704
Broadview	73 17 40.3	253 14 15.6	3.8862700
Graham	111 43 17.4	291 35 03.6	4.2810749
Rowland	183 45 23.0	3 45 50.3	4.1737351
Palmer	243 23 23.7	63 32 19.9	4.3331827
McCoy	272 30 14.2	92 39 25.9	4.2983645
Strong	313 26 09.2	133 32 00.8	4.2424222
Coleman	348 08 04.9	168 08 51.4	3.9115917

M'NAUGHTON, CLARION COUNTY.

On a bare, round knob, about 2½ miles southeast of Fisher post-office, in Mill Creek Township, on land belonging to David McNaughton.

Station mark: A sandstone post 36 by 9 by 9 inches, set 32 inches in the ground, 6 feet north of an east and west fence line, and in the center of top of post is cemented a bronze tablet, marked "U. S. Geological Survey—Pennsylvania."

Reference marks: A chestnut tree 8 inches diameter, S. 84° W., 59½ feet distant. A chestnut tree 8 inches diameter, S. 13° 30′ E., 28½ feet distant. A chestnut tree 8 inches diameter, S. 35° 30′ W., 51 feet distant (magnetic bearings).

[Latitude 41° 14′ 47.47″. Longitude 79° 13′ 01.19″.]

To station—	Azimuth.	Back azimuth.	Log. distance
	° ′ ″	° ′ ″	*Meters.*
Clever	12 54 49.4	192 50 37.0	4.6047255
Myers	49 18 40.4	229 08 24.6	4.4594577
Groce	76 19 09.7	256 10 22.7	4.2827486
Beels	91 26 38.6	271 09 39.4	4.5563276
Weaver	118 24 03.6	298 15 38.3	4.3062598

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WARNER, INDIANA COUNTY.

About 3 miles southwest of Indiana, in White Township, on the highest part of a bare, round-top hill, on land owned by Mr. Warner.

Station mark: A stone post 40 by 6 by 6 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 36′ 29.07″. Longitude 79° 13′ 10.50″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Tabernacle	49 50 22.8	229 44 45.4	4.2036595
Watt	80 57 13.6	260 54 54.0	3.7080738
Broadview	145 47 32.6	325 44 45.1	4.0310144
Kunkle	186 50 57.4	6 51 34.4	4.0482704
Coleman	224 03 29.4	44 04 52.9	3.6365727
Indiana Normal School cupola	258 35 32.4	78 37 54.9	3.7203033
Strong	273 44 25.4	93 50 53.6	4.1478120
Nolo	279 34 16.2	99 44 21.0	4.3458154
Evans	290 08 42.1	110 13 57.3	4.0841382
Widow	345 15 60.0	165 18 07.7	4.2604466

HILLSIDE, NORTH BASE, WESTMORELAND COUNTY.

On prolongation of Hillside tangent of Pennsylvania Railroad, in field owned by John Bridges, about one-third mile south of Gray railroad station.

Theodolite elevated 15 feet.

Station mark: A sandstone post 40 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

Reference marks: Iron bench-mark post set at right angles to tangent, on fence line, 7.56 feet distant from center of station mark. Iron bench-mark post eastward from station and at right angles to tangent, 31.2 feet distant from center of station mark.

[Latitude 40° 23′ 27.97″. Longitude 79° 14′ 32.56″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
South Base	36 34 11.5	216 33 08.0	3.5894711
Jellison	99 01 21.3	278 57 50.4	3.8904408
Kelly (observed azimuth)	169 17 18.1	349 16 41.8	3.8511056

KELLY, INDIANA COUNTY.

About 1½ miles north of Blairsville, in a cultivated field owned by James Kelly, 6 feet north of fence running east and west. A few small scattering trees near summit of hill.

Station mark: A stone post 40 by 8 by 8 inches, set 37 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 27′ 14.06″. Longitude 79° 15′ 28.54″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Jellison	47 49 30.9	227 46 36.1	3.9331709
Marshall	92 25 17.0	272 19 08.7	4.1357354
Tabernacle	127 10 55.2	307 06 47.7	4.0510686
Widow	273 35 33.0	93 39 09.9	3.8972129
Hillside, North base	349 16 41.8	169 17 18.1	3.8511056

HILLSIDE, SOUTH BASE, WESTMORELAND COUNTY.

On a level railroad dump in field owned by George Piper, three-fourths mile southward from Hillside railroad station, 16 feet westward from fence.

Theodolite elevated 25 feet.

Station mark: A sandstone post 40 by 8 by 8 inches, set 37 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

Reference marks: Iron bench-mark post set at right angles to tangent near fence, 14.97 feet from center of station mark. Iron bench-mark post eastward from railroad track, just inside of fence on bank, 109.17 feet from center of station mark.

[Latitude 40° 21′ 46.78″. Longitude 79° 16′ 10.68″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Jellison	128 58 47.4	308 56 20.1	3.8385728
Hillside, North base	216 33 08.0	36 34 11.5	3.5894711

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WATT, INDIANA COUNTY.

About 1 mile southwest of Tannery post-office and 1¾ miles northeast of Parkwood post-office, on the highest point of the western one of two hills about the same height and 1 mile apart. The land is owned by Thomas Watt.

Station mark: A stone post 42 by 8 by 8 inches, set 39 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 36′ 02.99″. Longitude 79° 16′ 45.32″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Jellison	11 37 51.5	191 35 46.3	4.3528660
Tabernacle	36 59 57.4	216 56 39.4	4.0758263
Hood	74 32 44.3	254 28 24.0	3.9896421
Broadview	174 05 29.2	354 05 01.4	3.9883854
Coleman	244 02 11.8	64 05 54.9	3.9520747
Warner	260 54 54.0	80 57 13.6	3.7080738
Evans	281 34 19.5	101 41 54.2	4.2248181
Widow	330 02 40.0	150 07 07.1	4.2877768

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BROADVIEW, INDIANA COUNTY.

About 3½ miles north of Shelocta and a few rods east of the Armstrong-Indiana County line, on a high, bare hill, with some timber on the southwest slope. The land is owned by John Russell.

Station mark: A stone post 42 by 8 by 8 inches, set 38 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 41′ 16.95″. Longitude 79° 17′ 28.00″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Tabernacle	17 47 44.1	197 44 53.7	4.3044854
Graham	131 45 43.1	311 40 54.2	4.1436489
Clever	173 07 19.6	353 06 02.8	4.3608128
Kunkle	253 14 15.6	73 17 40.3	3.8862700
Coleman	302 28 27.8	122 32 38.9	4.0307069
Warner	325 44 45.1	145 47 32.6	4.0310144
Watt	354 05 01.4	174 05 29.2	3.9883854

CLEVER, ARMSTRONG COUNTY.

On a high, cultivated ridge, with scattering dead trees, in Wayne Township, about 1 mile west of Belknap and 1 mile east of Snydersville (Muff post-office). The land belongs to G. H. Clever, of Belknap.

Station mark: A sandstone post 39 by 8 by 8 inches, set 27 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

Reference marks: Live chestnut tree, magnetic bearing S., 84° E., 45½ feet distant. Dead chestnut tree, N. 4° E., 121 feet distant. Fence on line between properties of G. H. Clever and Jeremiah Bowser bears due south, 3 feet distant.

[Latitude 40° 53′ 35.63″. Longitude 79° 19′ 25.41″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Graham	29 26 30.0	209 22 57.3	4.1909592
Leister	65 59 54.4	245 48 30.3	4.4288814
Templeton	93 16 57.6	273 06 31.1	4.3508735
Reynolds	120 59 58.2	300 50 42.0	4.3643865
McCall	130 01 44.6	309 51 31.4	4.4550873
Myers	147 47 30.2	327 41 28.6	4.3829142
McNaughton	192 50 37.0	12 54 49.4	4.6047255
Rowland	297 06 56.5	117 12 06.0	4.0951985
Broadview	353 06 02.8	173 07 19.6	4.3608128

JELLISON, WESTMORELAND COUNTY.

On a bare sharp hill near Salem Church, 5 miles southwest of Blairsville. Land is owned by Mr. Jellison, who lives on the north side of hill.

Station mark: A sandstone post 36 by 8 by 8 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 24′ 07.35″. Longitude 79° 19′ 57.99″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Harmon	48 24 46.9	228 20 39.6	4.0811381
Marshall	130 53 22.4	310 50 01.2	3.9852846
Tabernacle	168 10 21.9	348 09 09.5	4.1083487
Watt	191 35 46.3	11 37 51.5	4.3528660
Kelly	227 46 36.1	47 49 30.9	3.9331709
Widow	249 39 35.6	69 46 07.1	4.1810596
Hillside, North base	278 57 50.4	99 01 21.3	3.8904408
Hillside, South base	308 56 20.1	128 58 47.4	8.8385728

√ TABERNACLE, INDIANA COUNTY.

About one-half mile east of Clarksburg post-office and about 6 miles by road north of Saltsburg, on the highest part of a bare cultivated round-top hill owned by the heirs of S. W. Coleman.

Station mark: A stone post 40 by 6 by 6 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 30′ 54.57″. Longitude 79° 21′ 49.71″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Marshall	36 51 54.3	216 49 45.4	3.8917275
Hood	161 56 25.3	341 55 23.0	3.8611613
Broadview	197 44 53.7	17 47 44.1	4.3044854
Watt	216 56 39.4	36 59 57.4	4.0758263
Warner	229 44 45.4	49 50 22.8	4.2036595
Widow	293 21 31.4	113 29 15.9	4.2639820
Kelly	307 06 47.7	127 10 55.2	4.0516686
Jellison	348 09 09.5	168 10 21.9	4.1083487

LUCINDA CATHOLIC CHURCH, CLARION COUNTY.

(Not occupied.)

Station mark: Spire of church near Lucinda station, on Pittsburg and Western Railway.

[Latitude 41° 18′ 41.71″. Longitude 79° 21′ 58.24″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Myers	19 40 05.2	199 35 42.8	4.4416060
Beels	74 49 35.5	254 38 29.9	4.3862458
McNaughton	299 59 02.7	120 04 57.4	4.1594736

CLARION COURT-HOUSE, CLARION COUNTY.

(Not occupied.)

Station mark: Center of tower.

[Latitude 41° 12′ 55.22″. Longitude 79° 23′ 11.60″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Myers	26 19 26.3	206 15 52.3	4.2335056
Beels	101 12 14.0	281 01 57.4	4.3464047

HOOD, INDIANA COUNTY.

In Conemaugh Township, about 1 mile north of Elders Ridge post-office, on the highest point of a bare round-top hill owned by Calvin Hood.

Station mark: A stone post 28 by 8 by 8 inches, set 24 inches in the ground, resting on solid rock; in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 34′ 38.44″. Longitude 79° 23′ 25.45″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Marshall	10 26 05.9	190 24 59.2	4.1258931
Steel	47 52 51.9	227 47 34.0	4.1913671
Hilty	64 10 05.2	244 04 31.3	4.1281149
Watt	254 28 24.0	74 32 44.2	3.9896421
Tabernacle	341 55 23.0	161 56 25.3	3.8611613

GRAHAM, ARMSTRONG COUNTY.

About 1 mile east of Blanket Hill post-office, on a bare ridge of cultivated land owned by the Graham heirs and rented by W. A. Blose.

Station mark: A sandstone post 36 by 8 by 8 inches, set 32 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

Reference marks: Chestnut tree 24 inches diameter, magnetic bearing S. 23° W., distant 415 feet. Dead chestnut tree 18 inches diameter, S. 86° W., distant 257 feet.

[Latitude 40° 46′ 17.28″. Longitude 79° 24′ 50.74″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Shrader	73 49 24.6	253 39 11.0	4.3613318
Leister	98 40 56.3	278 33 05.5	4.2328320
Miller	120 00 41.6	299 55 18.5	4.1263694
Templeton	135 00 42.7	314 53 49.7	4.3203059
Reynolds	154 18 20.5	334 12 37.9	4.4504542
Clever	209 22 57.3	29 26 30.0	4.1909592
Rowland	247 12 03.4	67 20 45.1	4.3072670
Kunkle	291 35 03.6	111 43 17.4	4.2810749
Broadview	311 40 54.2	131 45 43.1	4.1436489

MARSHALL, WESTMORELAND COUNTY.

In Loyalhanna Township, about 3¼ miles southwest of Saltsburg, on the highest part of a bare flat hill which is the southwestern one of three near together. The land is owned by Mrs. William Marshall.

Station mark: A stone post 42 by 8 by 8 inches, set 38 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 27′ 32.39″. Longitude 79° 25′ 08.15″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Harmon	6 44 30.8	186 43 44.3	4.1592792
Steel	106 37 25.0	286 33 14.0	3.9778350
Hilty	126 59 37.0	306 55 10.2	4.0830968
Hood	190 24 59.2	10 26 05.9	4.1258931
Tabernacle	216 49 53.2	36 52 02.1	3.8917275
Kelly	272 19 08.7	92 25 17.0	4.1357354
Jellison	310 50 01.2	130 53 22.4	3.9852846

WEAVER, CLARION COUNTY.

About 1 mile south of Fryburg, in Washington Township, on a bare knob of cultivated land owned by J. G. Weaver, of Marble post-office.

Station mark: A sandstone post, 36 by 12 by 12 inches, set 32 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

Reference marks: Chestnut tree 12 inches diameter, magnetic bearing S. 63° W., 274 feet distant. Chestnut tree 22 inches diameter, N. 56° E., 238 feet distant. Oak tree 18 inches diameter, S. 55° E., 226 feet distant.

[Latitude 41° 19′ 58.86″. Longitude 79° 25′ 46.92″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
McCall	22 57 16.7	202 51 12.0	4.5204177
Myers	7 56 41.2	187 54 49.3	4.4577631
Beels	64 14 20.7	244 05 45.9	4.3046552
McNaughton	298 15 38.3	118 24 03.6	4.3062598

HARMON, WESTMORELAND COUNTY.

In Unity Township about 3 miles north of west of Latrobe, on a high ridge known locally as Dry Ridge. The ridge is flat on top and the station is near center of cleared field.

Station mark: A stone post 42 by 8 by 8 inches, set 38 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 19′ 47.78″. Longitude 79° 26′19.91″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Stroble	46 04 32.3	226 02 15.5	3.8409840
Marshall	186 43 44.3	6 44 30.8	4.1592792
Jellison	228 20 39.6	48 24 46.9	4.0811381
Kepple	110 05 16.9	289 59 32.2	4.1262722

GROCE, CLARION COUNTY.

About 2¾ miles air-line distance west of Clarion court-house, in Paint Township, on a low, uncultivated knob having a fringe of trees and bushes along a north and south fence running over the hill. The land belongs to John Groce, of Clarion.

Station mark: A sandstone post 42 by 8 by 8 inches, set 34 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

Reference marks: Wild cherry tree on fence line, magnetic bearing S. 75° E., 75 feet distant. Wild apple tree N. 55° W., 97 feet distant.

[Latitude 41° 12′ 19.69.″ Longitude 79° 26′ 20.87.″]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Myers	12 33 09.4	192 31 40.0	4.1643794
Beels	107 15 39.5	287 07 27.7	4.2598866
McNaughton	256 10 22.7	76 19 09.7	4.2827486

MYERS, CLARION COUNTY.

About 3 miles southeast of Sligo, in Toby Township, and near the main road between Clarion and East Brady, and about halfway between the two places, on a bare knob of cultivated land belonging to V. R. Myers, of Sligo.

Station mark: A sandstone post 36 by 8 by 8 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

Reference marks: Chestnut tree, magnetic bearing S. 65° E., 303 feet distant. Chestnut tree S. 55° W., 115 feet distant. Chestnut tree N. 84° W., 203 feet distant.

[Latitude 41° 04′ 37.67″. Longitude 79° 28′ 36.80″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Reynolds	39 10 40.8	219 07 25.6	4.0414047
McCall	76 45 26.6	256 41 14.5	3.9639954
Beels	144 07 19.6	324 00 37.9	4.3845964
Weaver	187 54 49.3	7 56 41.2	4.4577631
Groce	192 31 40.0	12 33 09.4	4.1643794
Lucinda Catholic church	199 35 42.8	19 40 05.2	4.4416060
Clarion court-house	206 15 52.3	26 19 26.3	4.2335056
McNaughton	229 08 24.6	49 18 40.4	4.4594577
Clever	327 41 28.6	147 47 30.2	4.3829142

MELLON, FAYETTE COUNTY.

About 2 miles north of Markleysburg and 600 feet north of Mellon's store, on hill covered with timber. Theodolite raised 18 feet on stump of tree and lines of sight cut out to other stations.

Station mark: A stone post 36 by 12 by 12 inches, set flush with surface of ground, in the center of top of which is cemented a copper bolt.

[Latitude 39° 44′ 48.18″. Longitude 79° 29′ 23.30″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Piney Swamp	5 29 47.3	185 28 53.8	4.3198719
Kelley	25 02 17.6	204 59 31.0	4.1674360
Wymp	82 07 39.3	261 57 14.8	4.3709214
Pondfield	102 56 31.1	282 48 22.5	4.2706993
Accident	308 24 44.6	128 32 14.0	4.3308574

STROBLE, WESTMORELAND COUNTY.

About 4 miles southeast of Greensburg, on a cleared ridge having timber on its western end; there is a higher summit 1 mile to eastward. The land is owned by John Stroble.

Station mark: A stone post 40 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 17′ 11.77″. Longitude 79° 29′ 51.34″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Altman	95 57 53.1	275 53 01.1	4.0302815
Kepple	141 08 28.0	321 05 00.3	4.0817032
Harmon	226 02 15.5	46 04 32.3	3.8409840

STEEL, WESTMORELAND COUNTY.

About 4 miles west of Saltsburg, on the southern part of summit of high, bare hill in Bell Township, on land owned by John Steel.

Station mark: A stone post 40 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 29′ 00.34″. Longitude 79° 31′ 34.73″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Kepple	22 23 34.0	202 21 12.9	4.1295269
Rose	52 15 25.4	232 08 55.2	4.2538871
Clearview	70 04 30.7	249 59 21.5	4.0770516
Bush Hill	125 41 21.6	305 39 26.9	3.7093968
Hilty	172 52 01.3	352 51 45.5	3.6629986
Hood	227 47 34.0	47 52 51.9	4.1913671
Marshall	286 33 14.0	106 37 25.0	3.9778330

HILTY, WESTMORELAND COUNTY.

In Bell Township, about 1½ miles north of Perrysville post-office, on the eastern part of a bare knob, and about 3 feet lower than the highest part of the hill, on land owned by S. McCauley.

Station mark: A stone post 40 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey—Pennsylvania."

Reference marks: Witness stones are set in the ground 6.3 feet north and 6.18 feet south of mark. A small wild apple tree is 79.3 feet northeast of mark.

[Latitude 40° 31′ 28.40″. Longitude 79° 31′ 59.01″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bush Hill	66 14 30.4	246 12 51.4	3.5933120
Hood	244 04 31.3	64 10 05.2	4.1281149
Marshall	306 55 10.2	126 59 37.0	4.0830968
Steel	352 51 45.5	172 52 01.3	3.6629986

MILLER, ARMSTRONG COUNTY.

In East Franklin Township, about 2 miles northwest of Kittanning, on a flat, cultivated hill owned by James Miller. It is 100 yards west of his brick house.

Station mark: A stone post 36 by 8 by 8 inches, set 34 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 49′ 53.90″. Longitude 79° 33′ 05.12″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Leister	52 11 10.0	232 08 42.0	3.8272558
Templeton	158 21 39.5	338 20 09.8	3.9397410
Graham	299 55 18.5	120 00 41.6	4.1263694

REYNOLDS, CLARION COUNTY.

On a round bare knob about 4½ miles northeast of East Brady, on road to Rimersburg. The land belongs to the heirs of Alex. Reynolds, of Kittanning, and is occupied by George Leonard.

Station mark: A sandstone post 36 by 10 by 10 inches, set 33 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

Reference marks: Chestnut tree with broken top, magnetic bearing S. 58° W., 98 feet distant. Wild cherry tree, 4 inches diameter, N. 73° W., 51 feet distant.

[Latitude 42° 00′ 01.14″. Longitude 79° 33′ 34.13″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Templeton	13 22 43.0	193 21 32.2	4.0389218
McCall	162 33 17.7	342 32 21.0	3.8277738
Myers	219 07 25.6	39 10 40.8	4.0414047
Clever	300 50 42.0	120 59 58.2	4.3643865
Graham	334 12 37.9	154 18 20.5	4.4504542

OVERTON, WESTMORELAND COUNTY.

About 15 feet northeast of a summit of hill 2 miles northeast of Scottdale and one-fourth mile west of the Painter coke ovens, on land owned by the McClure Coke Company.

Station mark: A stone post 36 by 8 by 8 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 06′ 07.38″. Longitude 79° 33′ 48.87″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Moore	57 24 28.2	237 22 19.4	3.7500275
Alverton	149 48 14.2	329 47 05.4	3.7013389

BUSH HILL, WESTMORELAND COUNTY.

In Washington Township, about 4 miles south of Apollo, on a bare hill owned by the heirs of Isaac Bush.

Signal: A lone apple tree on highest point of hill.

Station mark: A stone post 40 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 30′ 37.17″. Longitude 79° 34′ 31.41″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Clearview	45 00 25.5	224 57 11.0	3.9994467
Hilty	246 12 51.4	66 14 30.4	3.5933120
Steel	305 39 26.9	125 41 21.6	3.7093968

M'CALL, CLARION COUNTY.

On a bare flat knob about 1½ miles north of Bela post-office, 8 feet north of an east and west fence. The land belongs to William T. McCall.

Station mark: A sandstone post 36 by 8 by 8 inches, set 32 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

Reference marks: Chestnut tree 18 inches diameter, magnetic bearing N. 85° W., 185 feet distant. Chestnut tree 18 inches diameter S. 81° E.

[Latitude 41° 03′ 29.14″. Longitude 79° 35′ 00.49″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Beels	166 21 52.1	346 19 23.0	4.3497924
Weaver	202 51 12.0	22 57 16.7	4.5204177
Myers	256 41 14.5	76 45 26.6	3.9639954
Clever	309 51 31.4	130 01 44.6	4.4550873
Reynolds	342 32 21.0	162 33 17.7	3.8277738

KEPPLE, WESTMORELAND COUNTY.

On a ridge timbered on its northern end, 4 miles north of Jeannette and 8 miles northwest of Greensburg. The land is owned by Michael Kepple, who lives at foot of ridge on southeast side.

Station mark: A stone post 30 by 8 by 8 inches, set 26 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 22′ 16.36″. Longitude 79° 35′ 12.32″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Altman	20 24 19.7	200 22 55.2	3.9465750
Rose	99 13 02.3	279 08 53.6	3.9625866
Clearview	143 58 12.5	323 55 24.7	4.0157222
Steel	202 21 12.9	22 23 34.0	4.1295269
Stroble	321 05 00.3	141 08 28.0	4.0817032
Harmon	289 59 32.2	110 05 16.9	4.1262722

TEMPLETON, ARMSTRONG COUNTY.

About 1½ miles north of Middlesex (Cowansville post-office), in Sugar Creek Township, on a bare ridge with timber on the northwest side. The land is owned by Widow Templeton.

Station mark: A sandstone post 42 by 8 by 8 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

Reference mark: A wild cherry tree, 7 inches in diameter, magnetic bearing N. 8° W., 164 feet distant.

[Latitude 40° 54′ 16.17″. Longitude 79° 35′ 23.26″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Leister	9 43 23.3	189 42 25.0	4.0930300
Shrader	18 52 03.4	198 48 43.8	4.3503890
Reynolds	193 21 32.2	13 22 43.0	4.0389218
Clever	273 06 31.1	93 16 57.6	4.3508735
Graham	314 53 49.7	135 00 42.7	4.3203059
Miller	338 20 09.8	158 21 39.5	3.9397410

ALVERTON, WESTMORELAND COUNTY.

On the summit of the hill on which is located the Alverton cemetery, about 30 feet west of the westerly fence line of cemetery.

Station mark: A stone post 36 by 8 by 8 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 08′ 28.25″. Longitude 79° 35′ 35.68″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Moore	16 39 38.6	196 38 38.6	3.8863993
Regantown	81 52 06.7	261 49 08.7	3.8197812
Overton	329 47 05.4	149 48 14.2	3.7013389

LEISTER, ARMSTRONG COUNTY.

Six miles southwest of Kittanning, in North Buffalo Township, on a round knob, cleared on southeast side and timbered on northwest side. The land belongs to Sarah Jane Grey, of McHaddon.

Station mark: A sandstone post 40 by 8 by 8 inches, set 35 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

Reference mark: Oak tree 18 inches diameter, magnetic bearing N. 30° W., 77½ feet distant.

[Latitude 40° 47′ 40.31″. Longitude 79° 36′ 51.50″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Shrader	29 48 10.1	209 45 46.8	4.0155564
Templeton	189 42 25.0	9 43 23.3	4.0930300
Miller	232 08 42.0	52 11 10.0	3.8272558
Clever	245 48 30.3	65 59 54.4	4.4288814
Graham	278 33 05.5	98 40 56.3	4.2328320

MOORE, FAYETTE COUNTY.

On a hill locally known as Moore's Hill, 2 miles southwest of Scottdale, on the road between Scottdale and Dawson, on land owned by the H. C. Frick Coke Company.

Station mark: A stone post 36 by 8 by 8 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 04′ 29.12″. Longitude 79° 37′ 08.83″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Secrest	111 37 13.2	291 34 24.3	3.8251290
Regantown	146 04 20.5	326 02 22.6	3.8899346
Alverton	196 38 38.6	16 39 38.6	3.8863993
Overton	237 22 19.4	57 24 28.2	3.7500275

ALTMAN, WESTMORELAND COUNTY.

About 5 miles southwest of Greensburg and 1 mile south of Old Grapeville, on a flat, cleared hill with fringe of timber on the northern side, on land owned by John C. Altman.

Station mark: A stone post 44 by 8 by 8 inches, set 42 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 17′ 47.65″. Longitude 79° 37′ 22.85″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Shepler	45 51 12.3	225 43 46.0	4.3579395
Wiley	77 41 14.4	257 35 46.5	4.0885127
Rose	148 30 09.7	328 27 25.6	4.0584376
Kepple	200 22 55.2	20 24 19.7	3.9465750
Stroble	275 53 01.1	95 57 53.1	4.0302815

DUNBAR, FAYETTE COUNTY.

On a bald summit of Chestnut Ridge, one-fourth mile east of State Orphan School and about 5 miles by wagon road southeast of Uniontown.

Station mark: A stone post 42 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 39° 53′ 15.11″. Longitude 79° 38′ 38.67″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Keener	97 12 12.7	277 03 28.5	4.2915497
Work	170 44 31.3	350 43 35.0	4.1119491

BEELS, ON LINE BETWEEN CLARION AND VENANGO COUNTIES.

About 3 miles north of Salem, in Salem Township, on a bare, round knob with timber on the north side. On an east and west line fence, which is also the county line between Clarion and Venango counties. The land south of fence is owned by J. H. Beels, of Lamartine.

Station mark: A stone post 36 by 8 by 8 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

Reference marks: A chestnut tree along road fence, magnetic bearing S. 34° W., 188 *feet distant.* A county-line monument and corner *N. 87° W., 115 feet distant.*

[Latitude 41° 15′ 14.00″. Longitude 79° 39′ 47.07″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Weaver	244 05 45.9	64 14 20.7	4.3046552
Lucinda Catholic Church	254 38 29.9	74 49 35.5	4.3862458
McNaughton	271 09 39.4	91 26 38.6	4.5563276
Clarion court-house	281 01 57.4	101 12 14.0	4.3464047
Groce	287 07 27.7	107 15 39.5	4.2598866
Myers	324 00 37.9	144 07 19.6	4.3845964
McCall	346 19 23.0	166 21 52.1	4.3497924

CLEARVIEW, WESTMORELAND COUNTY.

In Franklin Township, about 4 miles north of Export, on high, bare, round knob owned by Joseph Cline.

Station mark: A stone post 40 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey—Pennsylvania."

Reference marks: A stone 8.1 feet north; stone 7.3 feet south; stone 8.5 feet west; stone 74 feet east.

[Latitude 40° 26′ 48.14″. Longitude 79° 39′ 31.12″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Rose	23 06 19.4	203 04 58.3	3.8762981
Bush Hill	224 57 11.0	45 00 25.5	3.9994467
Steel	249 59 21.5	70 04 30.7	4.0770516
Kepple	323 55 24.7	143 58 12.5	4.0157223

WORK, FAYETTE COUNTY.

On land owned by John Work, about 5 miles west of Connellsville and 9 miles north of Uniontown. A row of locust trees crosses top of hill along a north and south fence.

Station mark: A stone post 36 by 8 by 8 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

Reference mark: A nail driven at foot of locust tree 25½ feet distant, magnetic bearing of which is N. 30° E.

[Latitude 40° 00′ 09.20″. Longitude 79° 40′ 06.44″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Keener	59 13 04.4	239 05 15.9	4.3047205
Krepp	98 17 22.0	278 08 09.5	4.3136372
Dunbar	350 43 35.0	170 44 31.3	4.1119491

REGANTOWN, WESTMORELAND COUNTY.

On the summit of a hill in a cleared field, 100 feet east of a tree, one-half mile south of the State road and about 2 miles west of Regantown; about one-fourth mile northeast of a blacksmith shop on the road from Coal Hollow to the State road.

Station mark: A stone post 36 by 8 by 8 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 07′ 57.87″. Longitude 79° 40′ 11.80″.

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Secrest	25 18 26.5	205 17 35.4	3.6434487
Prospect	49 23 39.4	229 19 04.1	4.1254124
Shepler	100 33 11.2	280 27 34.5	4.0994919
Wiley	152 50 42.4	332 47 04.2	4.2430375
Alverton	261 49 08.7	81 52 06.7	3.8197812
Moore	326 02 22.6	146 04 20.5	3.8899346

SHRADER, ARMSTRONG COUNTY.

(Not occupied.)

On a bare ridge in South Buffalo Township, 3 miles northeast of Freeport, on land owned by A. C. Shrader, of Freeport.

Station mark: A sandstone post 40 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 42′ 48.68″. Longitude 79° 40′ 30.96″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Templeton	198 48 43.8	18 52 03.4	4.3503890
Leister	209 45 46.8	29 48 10.1	4.0155584
Graham	253 39 11.0	73 49 24.6	4.8813318

SECREST, WESTMORELAND COUNTY.

In the center of a cultivated field on a high summit of a long wooded ridge, locally known as Fort Hill, on land owned by W. M. Secrest, who lives about one-half mile northeast of station and about 2½ miles east of Layton post-office.

Station mark: A stone post 36 by 8 by 8 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 05′ 48.90″. Longitude 79° 41′ 31.20″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Prospect	60 16 23.6	240 12 39.4	3.9778269
Shepler	120 55 03.8	300 50 18.4	4.0870265
Regantown	205 17 35.4	25 18 26.5	3.6434487
Moore	291 34 24.3	111 37 13.2	3.8251290

ROSE, WESTMORELAND COUNTY.

About 4 miles north of Irwin on a cleared ridge owned by the Rose heirs.

Station mark: A stone post 40 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 23′ 03.83″. Longitude 79° 41′ 36.25″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wiley	25 50 13.1	205 47 29.0	4.1382508
Terrace	76 55 47.1	256 51 00.8	4.0297096
Clearview	203 04 58.3	23 06 19.4	3.8762981
Steel	232 08 55.2	52 15 25.4	4.2538871
Kepple	279 08 53.6	99 13 02.3	3.9625866
Altman	328 27 25.6	148 30 10.0	4.0584376

PONDFIELD, FAYETTE COUNTY.

On a high timbered summit of Chestnut ridge, about 4 miles air-line distance south of Fairchance and one-half mile north of Robert Rankin's house. Theodolite was elevated 25 feet and lines of sight were cut through timber toward other stations.

Station mark: A stone post 36 by 12 by 12 inches, set flush with the surface of the ground, in the center of top of which is cemented a *copper* bolt; 3 feet south of stump.

[Latitude 39° 46′ 57.92″. Longitude 79° 42′ 07.17″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wymp	34 25 25.2	214 23 09.0	3.9532404
Mellon	282 48 22.5	102 56 31.1	4.2706993
Kelley	325 31 36.8	145 36 58.1	4.3261837

WILEY, WESTMORELAND COUNTY.

About 5 miles north of West Newton and 6 miles southwest of Irwin, on a high ridge on farm belonging to Emily G. Wiley, of Yohoghany, whose house is about one-fourth mile south of signal.

Station mark: A stone post 36 by 8 by 8 inches, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 16′ 22.57″. Longitude 79° 45′ 49.85″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Shepler	18 11 18.3	198 09 19.3	4.1452190
Pollock	81 58 45.1	261 51 28.0	4.2080156
Calhoun	127 11 22.2	307 05 05.5	4.2365716
Terrace	155 55 00.9	335 52 58.9	4.0373270
Rose	205 47 29.0	25 50 13.1	4.1382508
Altman	257 35 46.5	77 41 14.4	4.0885127
Regantown	332 47 04.2	152 50 42.4	4.2430375

PROSPECT, FAYETTE COUNTY.

About 1¾ miles southeast of Redstone and 7 miles northeast of Brownsville, on a flat, bald hill having a large apple tree on summit. The land is owned by the heirs of Thomas Murphy and is occupied by J. C. Murphy, of Redstone.

Station mark: A stone post, 40 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 03′ 15.98″. Longitude 79° 47′ 19.34″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Keener	23 38 12.3	203 35 01.7	4.2448865
Krepp	74 26 58.4	254 22 24.1	4.0209121
Shepler	168 27 48.5	348 26 47.5	4.0497613
Regantown	229 19 04.1	49 23 39.4	4.1254124
Secrest	240 12 39.4	60 16 23.6	3.9778269

SHEPLER, WESTMORELAND COUNTY.

About 4 miles southeast of Belle Vernon and 5 miles east of Charleroi, on a high cultivated hill owned by John Shepler.

Station mark: A sandstone post, 32 by 8 by 8 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 09′ 12.22″. Longitude 79° 48′ 54.10″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Krepp	29 39 60.0	209 36 26.4	4.2009908
Hillsboro	71 44 42.6	251 34 48.6	4.3616006
Pollock	133 26 08.4	313 20 50.8	4.2046201
Wiley	198 09 19.3	18 11 18.3	4.1452190
Altman	225 43 46.0	45 51 12.3	4.3579395
Regantown	280 27 34.5	100 33 11.2	4.0994919
Secrest	300 50 18.4	120 55 03.8	4.0870265
Prospect	348 26 47.5	168 27 48.5	4.0497613

TERRACE, ALLEGHENY COUNTY.

About 2 miles east of McKeesport, on a high hill known as Fairview Terrace and owned by Alex. Faucett, of McKeesport.

Station mark: A sandstone post, 36 by 8 by 8 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 21′ 45.09″. Longitude 79° 48′ 58.31″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pollock	43 22 06.7	223 16 51.1	4.2251518
Calhoun	92 52 45.7	272 48 30.7	3.9684989
Rose	256 51 00.8	76 55 47.1	4.0297096
Wiley	335 52 58.9	155 55 00.9	4.0373270

KEENER, FAYETTE COUNTY.

About 8 miles west of Uniontown, 1½ miles north of McClellandtown, and 23.3 feet west of a lone locust tree on a bare knob owned by Ben Keener, who lives 300 yards south of station.

Station mark: A stone post, 40 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

Reference mark: A stone post, 36 by 12 by 12 inches, set 34 inches in the ground, in the center of top of which is cemented an aluminum bolt; azimuth from station 275°, 27′; distance, 20 feet.

[Latitude 39° 54′ 33.86″. Longitude 79° 52′ 16.00″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Fast	10 45 03.1	190 44 15.0	3.9804006
Turkey	51 08 33.2	231 04 02.8	4.1097964
Jefferson	93 07 26.3	273 01 04.2	4.1512351
Hillsboro	139 22 16.0	319 14 33.3	4.4181154
Krepp	166 57 58.6	346 56 35.3	4.1346730
Prospect	203 35 01.7	23 38 12.3	4.2448865
Work	239 05 15.9	59 13 04.4	4.3047205
Dunbar	277 03 28.5	97 12 12.7	4.2915497

FAST, FAYETTE COUNTY.

About 2 miles southeast of Masontown, on road to Smithfield, 8 feet north of an east and west fence on land owned by Mr. Fast, who lives about 300 yards south of station.

Station mark: A stone post, 36 by 10 by 10 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 39° 49′ 29.36″. Longitude 79° 53′ 30.97″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
St. Clair	10 01 47.4	190 00 37.0	4.1777734
Morley	47 17 02.2	227 11 58.5	4.1871165
Turkey	99 01 56.6	278 58 14.5	3.9215699
Jefferson	129 24 42.4	309 19 08.7	4.2041975
Keener	190 44 15.0	10 45 03.1	3.9804006

KREPP, WASHINGTON COUNTY.

About 1½ miles northwest of Brownsville, on a prominent and well-known bald knob owned by James Nickson.

Station mark: A sandstone post, 40 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 01′ 44.55″. Longitude 79° 54′ 25.69″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Jefferson	41 28 31.9	221 23 32.6	4.2228714
Hillsboro	115 13 26.6	295 07 06.8	4.1890430
Shepler	209 36 26.4	29 39 60.0	4.2009908
Prospect	254 22 24.1	74 26 58.4	4.0209121
Work	278 08 09.5	98 17 22.0	4.3136372
Keener	346 56 35.3	166 57 58.6	4.1346730
Turkey	18 00 10.1	197 57 02.7	4.3515150

CALHOUN, ALLEGHENY COUNTY.

About 2½ miles west of McKeesport and ½ mile south of Calhoun Park, on farm of W. F. Miller.

Station mark: A stone post 36 by 8 by 8 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 22′ 00.05″. Longitude 79° 55′ 32.00″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pollock	9 58 00.0	189 56 59.0	4.1096654
Shannon	84 27 17.4	264 23 27.5	3.9250637
Terrace	272 48 30.7	92 52 45.7	3.9684989
Wiley	307 05 05.5	127 11 22.2	4.2365716
Union U. P. Church	114 14 59.9	294 06 16.4	4.3196701
Greentree	150 34 16.3	330 30 36.5	4.2107475

POLLOCK, WASHINGTON COUNTY.

On Pollock's Hill, about 2 miles west of West Elizabeth, on road to Finleyville, 400 feet west of a rough board shanty on highest point of bare hill, owned by Mr. McClure.

Station mark: A sandstone post 40 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 15′ 08.99″. Longitude 79° 57′ 06.26″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hillsboro	29 10 08.6	209 05 31.5	4.3197152
Shannon	152 35 31.9	332 32 43.3	4.1259131
Calhoun	189 56 59.0	9 58 00.0	4.1096654
Terrace	223 16 51.1	43 22 06.7	4.2251518
Wiley	261 51 28.0	81 58 45.1	4.2080156
Shepler	313 20 50.8	133 26 08.4	4.2046201
Mount Wheeler	61 30 40.4	241 19 25.7	4.4496631
Canonsburg	87 29 40.3	267 20 47.3	4.2904183

TURKEY, GREENE COUNTY.

About 1 mile north of Sigsbee and 4 miles south of Carmichaels, on Turkey Knob, in a cultivated field owned by Leroy Hartley.

Station mark: A stone post 42 by 10 by 10 inches set flush with surface of ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 39° 50′ 11.72″. Longitude 79° 59′ 17.69″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Morley	14 32 17.4	194 30 55.5	4.0842057
Jefferson	154 58 31.5	334 56 40.0	3.9895121
Krepp	197 57 02.7	18 00 10.1	4.3515150
Keener	231 04 02.8	51 08 33.2	4.1097964
Fast	278 58 14.5	99 01 56.6	3.9215699
St. Clair	340 43 59.6	160 46 31.0	4.2327348

ALLEGHENY OLD OBSERVATORY, ALLEGHENY COUNTY.

On a hill near the center of the city of Allegheny.

Station mark: The center of dome.

[Latitude 40° 27′ 42.17″. Longitude 80° 00′ 44.09″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Allegheny New Observatory	161 31 39	341 31 18	3.38774
Greentree	170 00 46	350 00 29	3.56204

GREENTREE, ALLEGHENY COUNTY.

On the highest point of Greentree Hill, in extreme northwest part of city of Allegheny, on land belonging to the city. Summit of hill is covered with locust bushes 15 to 18 feet in height.

Theodolite elevated 25 feet.

Station mark: A sandstone post 38 by 8 by 8 inches, set 34 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 29′ 38.64″. Longitude 80° 01′ 10.95″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Shannon	1 26 42.8	181 26 32.4	4.1751665
Union U. P. Church	63 10 18.2	243 05 13.9	4.0926886
Dickson	90 57 02.2	270 46 45.3	4.3497228
Weir	129 06 28.3	309 00 30.5	4.2222866
Calhoun	330 30 36.5	150 34 16.3	4.2107476

ALLEGHENY NEW OBSERVATORY, ALLEGHENY COUNTY.

On the summit of a hill in Riverview Park, Allegheny.

Station mark: The center of main dome (in process of construction, 1900).

[Latitude 40° 28′ 57.26″. Longitude 80° 01′ 16.94″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Union U. P. Church	68 25 57	248 20 57	4.06917
Greentree	186 18 06	6 18 10	3.10864
Allegheny Old Observatory	341 31 18	161 31 39	3.38774

MORLEY, GREENE COUNTY.

On a flat bald ridge owned by D. W. Morley, 1 mile southeast of Bald Hill and one-half mile north of Pennsylvania-West Virginia State line. There are a few trees under brow of hill on east side.

Station mark: A stone post 42 by 12 by 12 inches, set flush with the surface of the ground, in the center of top of which is cemented a copper bolt.

[Latitude 39° 43′ 50.65″. Longitude 80° 01′ 25.65″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Turkey	194 30 55.5	14 32 17.4	4.0842057
Fast	227 11 58.5	47 17 02.2	4.1871165
Wymp	274 03 51.4	94 13 55.6	4.3536192
St. Clair	296 44 41.3	116 48 34.2	3.9880410
Reed	304 53 01.7	125 00 48.8	4.3278602
Waters	357 07 59.2	177 08 22.3	4.2373975

SHANNON, ALLEGHENY COUNTY.

About 1 mile south of Castle Shannon post-office, on a high, cultivated knob on which is one tree about 30 feet northeast of signal.

Station mark: A sandstone post 34 by 7 by 7 inches, sunk 33 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 21′ 33.53″. Longitude 80° 01′ 26.95″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Calhoun	264 23 27.5	84 27 17.4	3.9250637
Pollock	332 32 43.3	152 35 31.9	4.1259131
Canonsburg	46 20 22.0	226 14 17.1	4.2656474
Hickman	83 01 46.0	262 57 02.4	4.0175377
McDonald	90 53 55.8	270 46 02.6	4.2365717
Union U. P. Church	131 18 26.2	311 13 32.8	4.1524041
Greentree	181 26 32.4	1 26 42.8	4.1751665

JEFFERSON, GREENE COUNTY.

About 1 mile southeast of Jefferson, on a high bald knob owned by Lawrence Kraft.

Station mark: A stone post 36 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 39° 54′ 58.46″. Longitude 80° 02′ 11.35″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hillsboro	171 14 13.9	351 12 54.0	4.2860956
Krepp	221 23 32.6	41 28 31.9	4.2228713
Keener	273 01 04.2	93 07 26.3	4.1512351
Fast	309 19 08.7	129 24 42.4	4.2041975
Turkey	334 56 40.0	154 58 31.5	3.9895121
Hughes	104 02 35.8	283 56 38.3	4.1844974
Union	115 15 13.2	295 07 32.4	4.2747311

HILLSBORO, WASHINGTON COUNTY.

In a rocky pasture, about 1,000 feet north of Hillsboro church, about half way between Brownsville and Washington, along the National pike, on land owned by Mrs. E. S. Tonebaugh, who lives at crossing about 1,500 feet southeast of station.

Station mark: A stone post 30 by 8 by 8 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 05′ 17.67″. Longitude 80° 04′ 15.81″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pollock	209 05 31.5	29 10 08.6	4.3197152
Shepler	251 34 48.6	71 44 42.6	4.3616006
Krepp	295 07 06.8	115 18 26.6	4.1890430
Jefferson	351 12 54.0	171 14 13.9	4.2860956
Keener	319 14 33.3	139 22 16.0	4.4181154
Hughes	33 02 20.9	212 51 42.6	4.2751190
Union	51 48 48.2	231 42 26.5	4.2531028
Mount Wheeler	108 08 43.9	288 02 07.1	4.1859700
Canonsburg	151 42 44.5	331 38 29.5	4.2949237

MORRIS, GREENE COUNTY.

On land owned by Henry Morris, 5 miles southeast of Waynesburg, 3 miles east of Randolph Church; in cleared field 600 feet north of ridge road and one-fourth mile west of Mr. Morris's house.

Station mark: A marble post 48 by 8 by 8 inches, set 46 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 39° 52′ 02.67″. Longitude 80° 06′ 47.91″.]

To station—	Azimuth.	Back Azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Shriver	69 27 10.8	249 24 58.1	3.7205630
Hughes	142 37 23.6	322 34 23.6	4.0403635
Jefferson	230 25 41.6	50 28 38.8	3.9301943

HICKMAN, ALLEGHENY COUNTY.

On a bald hill in South Fayette Township, 2½ miles southwest of Bridgeville, on land belonging to William Hickman, who lives on south side of hill.

Station mark: A sandstone post 30 by 12 by 12 inches, set 28 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 20′ 52.33″. Longitude 80° 08′ 44.87″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Canonsburg	14 35 39.2	194 34 17.5	4.0787263
McDonald	102 26 54.8	282 23 45.3	3.8495728
Union U. P. Church	178 07 14.0	358 07 04.4	4.0271348
Shannon	262 57 02.4	83 01 46.0	4.0175377

UNION U. P. CHURCH, ALLEGHENY COUNTY.

A new brick church with a square tower on its northeast corner, situated on a hill 1 mile west of Remington, on the Steubenville pike.

Station mark: Center of tower.

[Latitude 40° 26′ 37.25″. Longitude 80° 08′ 59.69″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
McDonald	35 48 45.7	215 40 45.6	4.0503035
Dickson	117 40 04.8	297 34 52.5	4.1070426
Weir	173 11 33.3	353 10 40.1	4.2101067
Greentree	243 05 13.9	63 10 18.2	4.0926886
Calhoun	294 06 16.4	114 14 59.9	4.3196701
Shannon	311 13 32.8	131 18 26.2	4.1524041
Hickman	358 07 04.4	178 07 14.0	4.0271348

SHRIVER, GREENE COUNTY.

On a bald hill 2 miles west of Randolph Church and 4 miles south of Waynesburg, on land owned by William Shriver.

Station mark: A marble post 48 by 8 by 8 inches, set 46 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 39° 51′ 02.82.′ Longitude 80° 10′ 14.90″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Call	89 04 36.7	268 59 33.8	4.0507482
Hughes	170 36 15.8	350 35 28.6	4.0296854
Morris	249 24 58.1	69 27 10.8	3.7205630

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WEIR, ALLEGHENY COUNTY.

On a hill in Sewickley Township, about 3 miles north of Sewickley depot and 3 miles southeast of Economy; northwest of point of road called the "Three mile post," at the head of Turkey Run, on land owned by James F. Weir; 10 feet south of an east and west fence.

Station mark: A sandstone post 40 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 35′ 19.45″. Longitude 80° 10′ 21.45″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Dickson	42 46 12.4	222 41 52.7	4.1415233
Bunker Hill	110 53 26.0	290 47 55.1	4.1068604
Big Knob	170 47 47.7	350 46 41.6	4.1726934
Greentree	309 00 30.5	129 06 28.3	4.2222866
Union U. P. Church	353 10 40.1	173 11 33.3	4.2101067

CANONSBURG, WASHINGTON COUNTY.

In North Strabone Township, in a cultivated field at summit of high knob, 1 mile S. 15° E. of Canonsburg and in view of the town, on land owned by Mr. James Hanna, who lives on east side of hill, at a road fork.

Station mark: A sandstone post 31 by 7 by 7 inches, sunk 31 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 14′ 40.51″. Longitude 80° 10′ 51.20″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Mount Wheeler	22 31 03.0	202 28 40.8	4.1845757
Claysville	50 18 45.5	230 10 19.6	4.3826975
Garrett	78 04 35.4	257 59 04.1	4.0933003
McDonald	163 11 12.3	343 09 24.7	4.1326119
Hickman	194 34 17.5	14 35 39.2	4.0787263
Shannon	226 14 17.1	46 20 22.0	4.2656474
Pollock	267 20 47.3	87 29 40.3	4.2904183
Hillsboro	331 38 29.5	151 42 44.5	4.2949237

HUGHES, GREENE COUNTY.

On a hill covered with an orchard of small peach trees, about 4 miles north of Waynesburg, owned by the Hughes estate.

Station mark: A marble post, 36 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 39° 56′ 45.33″. Longitude 80° 11′ 28.53″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Call	41 26 18.6	221 22 02.6	4.1564204
Union	141 03 49.6	321 02 06.5	3.7827879
Hillsboro	212 57 42.6	33 02 20.9	4.2751190
Jefferson	283 56 38.3	104 02 35.8	4.1344974
Morris	322 34 23.6	142 37 23.6	4.0403635
Shriver	350 35 28.6	170 36 15.8	4.0296854

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BIG KNOB, BEAVER COUNTY.

Near the north end of summit and about 40 feet south of an east and west rail fence, on a prominent, partly timbered hill known locally as the "Big Knob," in Sewickley Township, on land owned by Joseph Powell, who lives at south end of knob; 4 miles northeast of Freedom, 6 miles east of Rochester, and 7½ miles east of Beaver court-house.

Theodolite elevated 30 feet.

Station mark: A sandstone post, 36 by 8 by 8 inches, set 34 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 43′ 15.73″. Longitude 80° 12′ 02.87″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bunker Hill	43 20 47.5	228 16 22.2	4.1441156
Dawson	83 55 01.0	263 47 05.7	4.2355940
Gilliland	109 42 02.6	289 35 24.5	4 1816755
Walker	143.47 07.7	323 43 30.5	4.1204228
Weir	350 46 41.6	170 47 47.7	4.1726934

M'DONALD, WASHINGTON COUNTY.

In a pasture at the highest point of a hill ½ mile south of McDonald, on land owned by Mr. William F. Wood, who lives on the southeast side of hill.

Station mark: A sandstone post 31 by 7 by 7 inches, set 55 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey—Pennsylvania."

Reference marks: A large black-oak line tree at the north boundary fence, 275 feet distant. A large white-oak line tree at the west boundary fence, 303 feet distant.

[Latitude 40° 21′ 41.66″. Longitude 89° 13′ 37.56″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Garrett	27 46 53.9	207 43 09.8	4.2450948
Dickson	162 21 09.3	342 18 57.4	4.1985263
Union U. P. Church	215 40 45.6	35 43 45.7	4.0503035
Shannon	270 46 02.6	90 53 55.8	4.2365717
Hickman	282 23 45.3	102 26 54.8	3.8495728
Canonsburg	343 09 24.7	163 11 12.8	4.1326119

UNION, GREENE COUNTY.

In a pasture on a prominent hill 9 miles north-northwest from Waynesburg and 1½ miles east of West Union.

Station mark: A sandstone post 48 by 8 by 8 inches, set 48 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 39° 59′ 18.24″. Longitude 80° 14′ 19.16″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Call	20 07 40.7	200 05 07.7	4.1355279
Bristoria	51 46 11.3	231 40 06.0	4.2357775
Time	73 20 36.0	253 14 48.2	4.1275671
Wheeler	178 04 16.4	358 04 01.9	4.2002916
Hillsboro	231 42 26.5	51 48 48.2	4.2531028
Jefferson	295 07 32.4	115 15 13.2	4.2747311
Hughes	321 02 06.5	141 03 49.6	3.7827879

WHEELER, WASHINGTON COUNTY.

On a sparsely timbered hill, 3 miles south of Washington, on land of William Courson, who lives at north base of hill.

Station mark: A marble post 38 by 6 by 6 inches, set 34 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 07′ 52.16″. Longitude 80° 14′ 31.71″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Claysville	78 01 54.2	257 55 51.0	4.1350995
Garrett	145 24 29.4	325 21 20.7	4.0856664
Canonsburg	202 28 40.8	22 31 03.0	4.1345757
Pollock	241 19 25.7	61 30 40.4	4.4496631
Hillsboro	288 02 07.1	108 08 43.9	4.1859700
Union	358 04 01.9	178 04 16.4	4.2002916

DICKSON, ALLEGHENY COUNTY.

On a hill in Findlay Township, 1 mile northeast of Clinton, on land owned by Prof. James Dickson.

Station mark: A sandstone post 40 by 8 by 8 inches, set 36 inches in the ground, in center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 29′ 49.59″. Longitude 80° 17′ 00.90″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
McCleary	135 46 56.7	315 41 54.9	4.1945450
Bunker Hill	170 08 04.4	350 06 58.6	4.1745591
Weir	222 41 52.7	42 46 12.4	4.1415223
Greentree	270 46 45.3	90 57 02.2	4.3497228
Union U. P. Church	297 34 52.5	117 40 04.8	4.1070426
McDonald	342 18 57.4	162 21 09.3	4.1985263

WALKER, BEAVER COUNTY.

On a flat, cultivated ridge in North Sewickley Township, 5 miles northeast of Beaver Falls, on land owned by Robert L. Walker.

Station mark: A sandstone post 40 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude, 40° 49′ 00.74″. Longitude, 80° 17′ 35.52″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gilliland	49 37 03.5	229 34 02.4	3.9313049
Jordan	111 54 15.1	291 5. 25.0	3.8175600
Big Knob	323 43 30.5	143 47 07.7	4.1204228

✓ CALL, GREENE COUNTY.

On a cleared hill about 3 miles southwest of Rogersville, on land owned by Robert Call.

Station mark: A marble post 48 by 8 by 8 inches, set 48 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude, 39° 50′ 56.68″. Longitude, 80° 18′ 07.61″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Oak	56 45 12.3	236 41 05.3	4.0403119
Bristoria	121 29 33.0	301 26 01.1	3.9642757
Time	148 14 24.8	328 11 10.5	4.1355279
Union	200 05 07.7	20 07 40.7	4.2167757
Hughes	221 22 02.6	41 26 18.6	4.1564204
Shriver	268 59 33.8	89 04 36.7	4.0507482

BUNKER HILL, BEAVER COUNTY.

On the highest point of a cleared hill in Moon Township, one-half mile south of Shaffer post-office and 6 miles south of Beaver; 200 yards south of Bunker Hill schoolhouse, on land owned by the Misses Good.

Station mark: A sandstone post 36 by 6 by 6 inches, set 34 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 37′ 47.00″. Longitude 80° 18′ 49.87″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
McCleary	67 11 43.7	247 07 52.4	3.9571732
Dawson	137 42 41.4	317 39 11.8	4.0500887
Big Knob	223 16 22.2	43 20 47.5	4.1441156
Weir	290 47 55.1	110 53 26.0	4.1068604
Dickson	350 06 53.6	170 08 04.4	4.1745591

GARRETT, WASHINGTON COUNTY.

In a cleared field owned by J. C. Garrett, 3 miles east of Buffalo Village and 5 miles northwest of Washington on the hill road to Hickory.

Station mark: A marble post 38 by 6 by 6 inches, set 35 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey—Pennsylvania."

Reference marks: Wire fence, west 113 feet. Large walnut tree N. 34° 30′ W., 433 feet.

[Latitude 40° 13′ 17.16″. Longitude 80° 19′ 24.18″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Claysville	26 32 31.5	206 29 36.5	4.1577265
West Liberty	79 22 34.7	259 11 49.0	4.3816589
West Middleton	103 12 36.6	283 07 53.7	4.0266996
McDonald	207 43 09.8	27 46 53.9	4.2450948
Canonsburg	257 59 04.1	78 04 35.4	4.0933003
Mount Wheeler	325 21 20.7	145 24 29.4	4.0856664

JORDAN, BEAVER COUNTY.

On a cultivated ridge in Big Beaver Township, on land owned by Sam Marshall, who lives on northwest side of ridge, 75 yards from station.

Station mark: A sandstone post 40 by 7 by 7 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 50′ 20.12″. Longitude 80° 21′ 55.70″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gilliland	2 52 26.6	182 52 15.4	3.9026731
Walker	291 51 25.0	111 54 15.1	3.8175600

GILLILAND, BEAVER COUNTY.

On a cleared hill 4 miles west of Beaver Falls, on land owned by Sarah J. Gilliland.

Theodolite elevated 33 feet.

Station mark: A sandstone post 42 by 7 by 7 inches, set 38 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 46′ 01.35″. Longitude 80° 22′ 12.78″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Dawson	21 51 14.9	201 49 57.4	3.8743981
Jordan	182 52 15.4	2 52 26.6	3.9026731
Walker	229 34 02.4	49 37 03.5	3.9313049
Big Knob	289 35 24.5	109 42 02.6	4.1816755

TIME, GREENE COUNTY.

In a pasture owned by the Miller estate, on a cleared knob 2½ miles north of Graysville and 1 mile west of Time post-office.

Station mark: A marble post 48 by 8 by 8 inches, set 48 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 39° 57′ 13.23″. Longitude 80° 23′ 10.56″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bristoria	5 30 19.2	185 30 01.5	3.8348950
Rock Lick	51 55 51.4	231 50 19.0	4.1943297
Wilsons Knob	111 17 45.4	291 10 43.8	4.2228433
Union	253 14 48.2	73 20 36.0	4.1275671
Call	328 11 10.5	148 14 24.8	4.1355279

BRISTORIA, GREENE COUNTY.

On a dome-shaped hill 2 miles north of Bristoria and 14 miles west of Waynesburg, in a pasture owned by the Isenminger estate, about 500 feet north of a public road.

Station mark: A marble post 48 by 8 by 8 inches, set 48 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 39° 53′ 32.55″. Longitude 80° 23′ 38.18″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Oak	6 54 26.4	186 53 51.1	4.0377279
Rock Lick	76 18 21.5	256 13 07.0	4.0791962
Wilson Knob	130 48 17.3	310 41 33.7	4.2948978
Time	185 30 01.5	5 30 19.2	3.8348950
Union	231 40 06.0	51 46 11.3	4.2357775
Call	301 26 01.1	121 29 33.0	3.9642757

CLAYSVILLE, WASHINGTON COUNTY.

On a cone-shaped hill 1 mile south of Claysville, on cultivated land belonging to Mr. J. Mosier.

Station mark: A marble post 38 by 6 by 6 inches, set 34 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey—Pennsylvania."

Reference marks: Double chestnut tree, south, 72 feet. Apple tree, east, 80 feet.

[Latitude 40° 06′ 20.01″. Longitude 80° 23′ 55.46″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
West Liberty	115 59 25.6	295 51 35.6	4.2830742
Independence	143 11 59.2	323 06 27.6	4.3069361
West Middleton	165 32 56.6	345 31 09.1	4.1983776
Garrett	206 29 36.5	26 32 31.5	4.1577265
Canonsburg	230 10 19.6	50 18 45.5	4.3826975
Mount Wheeler	257 55 51.0	78 01 54.2	4.1350995

DAWSON, BEAVER COUNTY.

Seventy yards west of a brick schoolhouse, on a cleared knob in western part of Brighton Township, 5 miles west of Beaver; near forks of road and on land owned by G. W. Dawson, of Beaver.

Station mark: A sandstone post 38 by 7 by 7 inches, set 34 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 42′ 16.02″. Longitude 80° 24′ 11.58″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
McCleary	3 49 22.4	183 49 00.5	4.0733912
Gilliland	201 49 57.4	21 51 14.9	3.8743981
Big Knob	263 47 05.7	83 55 01.0	4.2355940
Bunker Hill	317 39 11.8	137 42 41.5	4.0500887

OAK, GREENE COUNTY.

On a high cleared hill 1 mile south of Centennial Church, 3 miles south of Higley, and 6 miles south of Bristoria, on land owned by Dr. S. T. Williams.

Station mark: The lone signal tree on highest point of hill.

[Latitude 39° 47′ 41.45″. Longitude 80° 24′ 33.31″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Rock Lick	127 39 19.7	307 34 40.8	4.1163332
Bristoria	186 53 51.1	6 54 26.4	4.0377279
Call	236 41 05.3	56 45 12.3	4.0403119

M'CLEARY, BEAVER COUNTY.

On a hill in Raccoon Township 1 mile southwest of McCleary post-office, on land owned by A. L. Moore. Summit of hill has a few trees on its western side.

Station mark: A sandstone post 38 by 8 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 35′ 52.99″. Longitude 80° 24′ 45.11″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Dawson	183 49 00.5	3 49 22.4	4.0733912
Bunker Hill	247 07 52.4	67 11 43.7	3.9571732
Dickson	315 41 54.9	135 46 56.7	4.1945450

CROSS CREEK, WASHINGTON COUNTY.

On pasture land belonging to Mr. Hugh Lee, one-fourth mile southwest of Cross Creek Village. The north side of the hill is timbered. The property is leased by Mr. B. S. Stiffier.

Station mark: A marble post 38 by 6 by 6 inches, set 34 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey—Pennsylvania."

Reference marks: Fence, north, 85.5 feet. Chisel mark on rock outcrop, east, 76.2 feet.

[Latitude 40° 19′ 22.50″. Longitude 80° 25′ 08.80″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
West Middleton	14 00 35.4	193 59 35.1	3.9598141
Independence	52 47 51.5	232 43 06.7	4.1163188

WEST MIDDLETON, WASHINGTON COUNTY.

On the highest point of a partly cleared hill 1 mile west of West Middleton on the road to Wellsburg, W. Va., and on land owned by Robert D. Craig, who lives due north of station.

Station mark: A marble post 38 by 6 by 6 inches, set 34 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey—Pennsylvania."

[Latitude 40° 14′ 35.72″. Longitude 80° 26′ 42.16″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
West Liberty	62 37 50.9	242 31 47.8	4.1755802
Independence	96 31 51.9	276 28 07.6	3.9168898
Cross Creek	193 59 35.1	14 00 35.4	3.9398141
Garrett	283 07 53.7	103 12 36.7	4.0266996
Claysville	345 31 09.1	165 32 56.6	4.1983776

SMITH FERRY, BEAVER COUNTY.

An astronomic station of the United States Coast and Geodetic Survey, situated on the north bank of the Ohio River in front of the hotel at Smith Ferry.

[Latitude 40° 38′ 48.07″. Longitude 80° 30′ 05.06″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	Meters.
Graveyard	1 00 27.20	181 00 26.70	3.0124143
Island	59 02 52.20	239 01 44.40	3.4552858

Meridian Marks.

WASHINGTON, WASHINGTON COUNTY.

Location of station: A few feet north of sidewalk, on the south side of and near the southwest corner of the campus of Washington and Jefferson College.

Station mark: A sandstone post 48 by 12 by 12 inches, set about 40 inches in the ground, in the center of top of which is cemented a bronze meridian tablet.

Distant mark: North of station 482 feet; a sandstone post about 48 by 12 by 12 inches, set about 36 inches in the ground, in the center of top of which is cemented a bronze meridian tablet.

MARYLAND.

Triangulation Stations.

Three primary stations were established in 1899 in Garrett and Washington counties by Mr. Sledge Tatum, in conjunction with the extension of the work into West Virginia and Pennsylvania.

ROMAN NOSE, GARRETT COUNTY.

On a long ridge of same name, 5 miles air-line distance northeast of Oakland, on a narrow backbone about 30 feet lower than flat summit one-half mile southwest. Theodolite elevated 16 feet on stump of tree, and lines of sight cut through timber to other signals.

Station mark: Stump of tree.

[Latitude 39° 28′ 47.90″. Longitude 79° 22′ 1″.59″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	Meters.
Piney Swamp	125 30 37.5	305 25 13.3	4.1744346
Accident	202 20 36.5	22 23 33.6	4.2416865
High Rock	253 00 44.3	73 11 12.9	4.3921308

QUIRAUK.

On line between Frederick and Washington counties, about 2 miles *south of Penmar*, Pa., and about 2 miles southeast of Blue Mountain, Maryland. On highest point of mountain locally known by same name.

Theodolite elevated on an iron observation tower 84 feet.

Station mark: A bronze tablet marked "U. S. Geological Survey—Pennsylvania," countersunk in a dressed stone 4 feet long and 10 inches square, set flush with top of ground under center of tower.

[Latitude 39° 41′ 47.92″. Longitude 77° 30′ 45.72″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Lookout	19 48 57.1	199 44 32.5	4.4668329
Martin	75 49 48.7	255 41 01.2	4.3078569
Fairview	83 35 53.1	263 18 22.7	4.5962555
Parnell	129 18 20.6	309 04 53.8	4.5874493
Chambersburg	154 39 25.8	334 33 43.9	4.4715130

MARTIN, WASHINGTON COUNTY.

About one-half mile northwest of Hagerstown and 1,000 feet north of National pike, on high ground, in cleared field owned by Nicholas Martin.

Station mark: A copper bolt cemented in solid rock, under center of signal.

[Latitude 39° 39′ 05.84″. Longitude 77° 44′ 31.97″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Fairview	91 32 00.1	271 23 17.5	4.2907580
Quirauk	255 41 01.2	75 49 48.7	4.3078568
Lookout	336 28 18.0	156 32 39.7	4.3911174
Parnell	160 42 52.2	340 38 14.6	4.4941249

WEST VIRGINIA.

Triangulation Stations.

In conjunction with the extension of primary triangulation into Pennsylvania in 1899, Mr. Sledge Tatum, topographer, established six stations in Preston and Monongalia counties, and during the season of 1900 Mr. W. T. Griswold, topographer, established nine stations in Marshall, Ohio, Brooke, and Hancock counties, while engaged in the extension of triangulation from Greene County, Pa., into eastern Ohio.

PINEY SWAMP, PRESTON COUNTY.

About 1 mile northwest of Cranesville, on Piney Swamp Knob.

Station mark: A stone post 36 by 12 by 12 inches, set flush with surface of ground, in center of top of which is cemented a copper bolt.

[Latitude 39° 38′ 29.03″. Longitude 79° 30′ 47.10″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Reed	104 54 36.5	284 42 51.1	4.4365044
Wymp	129 32 53.4	309 23 23.6	4.4407570
Kelley	150 30 10.5	330 28 17.6	3.9334630
Mellon	185 28 53.8	5 29 47.3	4.3198719
Accident	248 16 18.1	68 24 40.0	4.3057954
Roman Nose	305 25 13.3	125 30 37.5	4.1744346

KELLEY, PRESTON COUNTY.

On a bald knob locally known by same name, about 6 miles south of Brandonville, Pa., and 8 miles north of Cranesville, W. Va.

Station mark: A copper bolt cemented in a stone post 36 by 12 by 12 inches, set flush with surface of ground.

[Latitude 39° 37′ 31.13″. Longitude 79° 33′ 44.23″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wymp	120 36 35.7	300 28 58.6	4.2970427
Pondfield	145 36 58.1	325 31 36.8	4.3261837
Mellon	204 59 31.0	25 02 17.6	4.1674360
Piney Swamp	330 28 17.6	150 30 10.5	3.9334630

WYMP GAP, MONONGALIA COUNTY.

On high summit 1 mile southwest of Wymp Gap, in Chestnut Ridge, about 9 miles air-line distance northeast of Morgantown, W. Va., and 16 miles south of Uniontown, Pa.

Station mark: A stone post 36 by 12 by 12 inches, set flush with surface of ground, in the center of top of which is cemented a copper bolt.

[Latitude 39° 42′ 57.71″. Longitude 79° 45′ 40.28″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Reed	25 47 12.2	205 44 55.7	4.0688994
Waters	54 18 28.5	234 08 48.4	4.4268308
St. Clair	78 48 54.2	258 42 43.2	4.1494319
Morley	94 13 55.6	274 08 51.4	4.3536430
Pondfield	214 23 09.0	34 25 25.3	3.9532404
Mellon	261 57 14.8	82 07 39.3	4.3709214
Kelley	300 28 58.6	120 36 35.7	4.2970427
Piney Swamp	309 23 23.6	129 32 53.4	4.4407570

REED, MONONGALIA COUNTY.

On a high summit of Chestnut Ridge, in a clear field, about 9 miles southeast of Morgantown and 1 mile west of Cheat River, on land owned by James Reed.

Station mark: A copper bolt cemented in solid rock.

[Latitude 39° 37′ 15.52″. Longitude 79° 49′ 14.01″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Waters	73 05 08.2	252 57 44.9	4.2392948
Morley	125 00 48.8	304 53 01.7	4.3278602
St. Clair	131 45 51.4	311 41 57.2	4.0691343
Wymp	205 44 55.7	25 47 12.2	4.0688994
Kelley	268 40 25.8	88 50 18.7	4.3459915
Piney Swamp	284 42 51.1	104 54 36.5	4.4365044

ST. CLAIR, MONONGALIA COUNTY.

In a pasture on a bald hill owned by Mr. E. H. St. Clair, about 4 miles northeast of Morgantown and 1½ miles south of Stewarttown.

Station mark: A bronze tablet countersunk and cemented in a dressed stone, 42 by 12 by 12 inches, set flush with surface of ground.

[Latitude 39° 41′ 28.58″. Longitude 79° 55′ 21.04.″]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Waters	31 21 02.2	211 17 32.7	4.1780100
Morley	116 48 34.2	296 44 41.3	3.9880410
Turkey	160 46 31.0	340 43 59.6	4.2327348
Fast	190 00 37.0	10 01 47.4	4.1777734
Wymp	258 42 43.2	78 48 54.2	4.1494319
Reed	311 41 57.2	131 45 51.4	4.0691343

WATERS, MONONGALIA COUNTY.

On a cleared knob owned by Mr. J. S. Waters, about 7 miles southwest of Morgantown, and 1½ miles north of Little Falls.

Station mark: A stone post 36 by 12 inches, set flush with surface of ground, in the center of the top of which is cemented a copper bolt.

[Latitude 39° 34′ 31.27″. Longitude 80° 00′ 49.45″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Morley	177 08 22.3	357 07 59.2	4.2373975
St. Clair	211 17 32.7	31 21 02.2	4.1780100
Wymp	234 08 48.4	54 18 28.5	4.4268307
Reed	252 57 44.9	73 05 08.2	4.2392948

WILSONS KNOB, MARSHALL COUNTY.

Situated in Sand Hill district, on the farm of Mr. G. H. Wilson, near the line fence between the lands of Mr. Wilson and Mr. Howard, where fence crosses summit of hill. The Moundsville and Washington pike passes over north side of hill.

Station mark: A cut marble post 48 by 6 by 6 inches, set 40 inches in the ground, in center of top of which is cemented a bronze triangulation tablet.

[Latitude 40° 00′ 29.42″. Longitude 80° 34′ 06.77″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Time	291 10 43.8	111 17 45.4	4.2228433
Bristoria	310 41 33.7	130 48 17.3	4.2943973
Rocklick	348 12 04.9	168 13 33.5	4.2053434

ROCKLICK, MARSHALL COUNTY.

Situated on a bare hill one-half mile south of the town of Rocklick, W. Va. A county road passes on north side of hill.

Station mark: A cut marble post 48 by 6 by 6 inches, set 36 inches in the ground, in center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 52′ 00.15″. Longitude 80° 31′ 48.73″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wilsons Knob	168 13 33.5	348 12 04.9	4.2053434
Time	231 50 19.0	51 55 51.4	4.1943297
Bristoria	256 13 07.0	76 18 21.5	4.0791962
Oak	307 34 40.8	127 39 19.7	4.1163332

WEST ALEXANDER, OHIO COUNTY.

(Secondary station.)

Situated on a hill 1 mile west of the town of West Alexander, Pa.

Station mark: A cut marble post 40 by 6 by 6 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

Reference marks: A maple tree 2 feet in diameter bears N. 85° 56′ W., distance 72.1 feet; a butternut tree 10 inches in diameter bears S. 52° 25′ E., distance 15 feet.

[Latitude 40° 05′ 48.62″. Longitude 80° 31′ 41.59″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wilsons Knob	19 15 19.31	199 13 46.06	4.0179782
Sherrard	50 30 02.08	230 23 48.15	4.2521001

INDEPENDENCE, BROOKE COUNTY.

Situated 2 miles southwest of the village of Independence, Pa., on a grassy hill on land owned by Mr. Gest. There is a small bunch of locust trees on south side of hill; also a short line of locust trees on east side, near summit.

Station mark: A cut marble post 40 by 6 by 6 inches, sunk 30 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 40° 15′ 06.03″. Longitude 80° 32′ 29.32″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
West Liberty	33 01 42.51	212 59 23.54	3.9704718
Mount Pleasant	58 27 33.56	238 17 59.54	4.3938130
New Alexander	106 07 03.27	286 01 22.01	4.1133566

ALLISON, HANCOCK COUNTY.

Situated 3 miles south of the village of East Liverpool, on a cleared hill on land owned by Mr. Allison.

Station mark: A cut marble post 48 by 6 by 6 inches, sunk 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 40° 35′ 42.41″. Longitude 80° 34′ 01.89″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Elders	89 54 31.77	269 43 49.10	4.3659427
Hammond	133 48 37.93	313 44 30.76	4.0918031
Cow Pasture	209 41 34.97	29 43 00.50	3.7946464

WEST LIBERTY, OHIO COUNTY.

Situated one-half mile north of the village of West Liberty, on the highest point of a bare hill. A county road passes along east side of hill.

Station mark: A cut marble post 48 by 6 by 6 inches, set 40 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 40° 10′ 52.03″. Longitude 80° 36′ 04.55″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sherrard	20 00 34.66	199 57 09.72	4.3437009
Mount Pleasant	72 16 23.96	252 09 09.19	4.2241846
New Alexander	147 07 42.89	327 04 20.90	4.1338984
Independence	212 59 23.54	33 01 42.51	3.9704758

CLINTON, OHIO COUNTY.

(Secondary station, not occupied.)

Lone tree at intersection of fences on highest point of hill near Clinton post-office.

[Latitude 40° 07′ 13.93″. Longitude 80° 39′ 05.59″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sherrard	13 04 52.84	193 03 24.54	4.1578221
Myers	44 17 52.96	224 11 47.70	4.2850889
Wilsons Knob	330 21 55.03	150 25 05.10	4.1567300

SHERRARD, MARSHALL COUNTY.

Situated 1 mile west of the village of Sherrard on a small hill in a cleared field on the farm of Mr. Joseph Koty, at the intersection of the Boggs Run and Benwood roads.

Station mark: A cut marble post, 48 by 6 by 6 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 59′ 39.70″. Longitude 80° 41′ 22.81″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Riggs Knob	19 21 27.57	199 18 53.15	4.2370223
Myers	91 09 22.42	271 04 45.82	4.0090858
Centennial	124 04 47.46	304 01 30.34	3.9432300
Mount Pleasant	151 39 31.51	331 35 42.42	4.2492017
Clinton	193 03 24.54	13 04 52.84	4.1578221
Liberty	199 57 09.72	20 00 34.66	4.3437009
West Alexander	230 23 48.15	50 30 02.08	4.2521000
Wilsons Knob	261 30 28.43	81 35 08.88	4.0196571
Rock Lick	316 02 51.78	136 09 00.37	4.2936870

RIGGS KNOB, MARSHALL COUNTY.

Situated 6 miles south of the town of Moundsville on the highest point of a cone-shaped hill locally known as Riggs Knob.

Station mark: A lone locust tree, 18 inches in diameter. Center of tree where first limb leaves trunk.

[Latitude 39° 50′ 51.66″. Longitude 80° 45′ 23.44″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Beallsville	89 53 56.89	269 45 19.11	4.2835700
Myers	164 43 47.81	344 41 46.06	4.2327314
Sherrard	199 18 53.15	19 21 27.57	4.2370223
Wilsons Knob	221 59 08.76	42 06 23.22	4.3802400
Rock Lick	263 41 30.14	83 50 12.37	4.2897152

OHIO.

Triangulation Stations.

The following triangulation stations in eastern Ohio were established by Mr. W. T. Griswold during the field season of 1900, and result from the extension of the work in Maryland, Pennsylvania, and West Virginia, from Maryland Heights and Sugarloaf, stations of the Coast and Geodetic Survey, the positions given being on the United States standard datum.

EAST LIVERPOOL, COLUMBIANA COUNTY.

(Not occupied.)

Memorial chapel in the cemetery at East Liverpool.

Station mark: Cap on monument of soldier.

[Latitude 40° 38′ 15.62″. Longitude 80° 34′ 24.10″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hammond	114 30 16.57	294 26 23.76	3.96492
Allison	353 41 30.73	173 41 45.23	3.67712

HAMMOND, COLUMBIANA COUNTY.

Situated 2 miles east of the village of Glasgow, on the highest point of a knob known locally as "Hammonds Knob."

Station mark: A cut marble post 40 by 6 by 6 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, marked "U. S. Geological Survey, Ohio."

[Latitude 40° 40′ 19.50″. Longitude 80° 40′ 21.46″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wintersville	9 29 54.97	189 27 36.41	4.4836287
Elders	58 57 24.93	238 50 48.93	4.2224370
Kensington	103 44 59.61	283 34 21.24	4.3739205
East Liverpool	294 26 23.76	114 30 16.57	3.9649200
Allison	313 44 30.76	133 48 37.93	4.0918031

NEW ALEXANDER, JEFFERSON COUNTY.

Situated 1 mile southwest of the village of New Alexander, in a cleared field on west side of county road, a quarter mile beyond point at which it leaves the New Alexander and Bloomingdale pike.

Station mark: A cut marble post 24 by 6 by 6 inches, sunk 2 feet below surface of the ground, in center of top of which is cemented a bronze triangulation tablet.

Reference marks: Large tree, true bearing N. 53° 20′ E., distant 272 feet. Small tree, true bearing S. 1° 36′ W., distant 131 feet. Old stump in field, true bearing N. 68° 36′ W., distant 14.7 feet.

[Latitude 40° 17′ 02.55″. Longitude 80° 41′ 17.28″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Mount Pleasant	27 21 07.51	207 17 14.17	4.2700856
Hopedale	110 23 39.92	290 17 09.61	4.1817202
Wintersville	164 08 12.73	344 06 30.92	4.1325490
Independence	286 01 22.01	106 07 03.27	4.1133566
West Liberty	327 04 20.90	147 07 42.89	4.1338982

WINTERSVILLE, JEFFERSON COUNTY.

Situated 2 miles northwest of the village of Wintersville, on a cone-shaped hill on land owned by Mr. Mays. The Wintersville and New Richmond pike passes over east side of hill.

Station mark: A cut marble post 40 by 6 by 6 inches, sunk 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet, marked "U. S. Geological Survey, Ohio."

[Latitude 40° 24′ 05.70″. Longitude 80° 43′ 54.56″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hopedale	53 36 19.90	233 31 31.07	4.1166735
Jefferson	94 42 21.10	274 33 35.99	4.2824762
Elders	156 33 37.87	336 29 21.35	4.3682786
Hammond	189 27 36.41	9 29 54.97	4.4836287
New Alexander	344 06 30.92	164 08 12.73	4.1325490

CENTENNIAL, BELMONT COUNTY.

(Secondary station.)

Situated 2½ miles northwest of the city of Bellaire, on land owned by William Nichol.

Station mark: A lone pine tree on highest point of hill.

[Latitude 40° 02′ 19.01″. Longitude 80° 46′ 29.36″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Myers	31 55 36.99	211 54 17.38	3.7445933
Sherrard	304 01 30.34	124 04 47.46	3.9432353

MOUNT PLEASANT, BELMONT COUNTY.

Situated near Morningview post-office, on the north end of a bare hill on the west side of the Wheeling and Mount Pleasant pike, on land owned by Mr. Goff.

Station mark: A cut marble post 40 by 6 by 6 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey, Ohio."

[Latitude 40° 08′ 06.07″. Longitude 80° 47′ 18.73″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Myers	6 32 00.56	186 31 12.65	4.1908702
Gallaway	48 45 10.24	228 38 05.78	4.3180322
St. Clairsville	58 03 07.29	237 58 45.00	4.0555471
Clarks Hill	77 26 58.01	257 20 13.51	4.1827579
Cadiz court-house	130 39 47.88	210 31 40.34	4.3715300
Cadiz	133 05 59.66	312 57 37.85	4.4004381
Hopedale	165 20 26.93	345 17 50.68	4.3534510
New Alexander	207 17 14.17	27 21 07.51	4.2700856
Independence	238 17 59.54	58 27 33.56	4.3938130
West Liberty	252 09 09.19	72 16 23.96	4.2241846
Sherrard	331 35 42.42	151 39 31.51	4.2492017

MYERS, BELMONT COUNTY.

Situated 4 miles southwest of the city of Bellaire, on a cleared knob on land owned by Mr. P. B. Myers.

Station mark: A cut marble post 48 by 6 by 6 inches, set 40 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey, Ohio."

[Latitude 39° 59′ 46.16″. Longitude 80° 48′ 33.17″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Beallsville	41 39 03.80	221 32 26.97	4.3447990
Jacobsburg	68 34 01.77	248 31 07.18	3.8405264
Gallaway	96 59 49.03	276 53 33.03	4.1453970
Mount Pleasant	186 31 12.65	6 32 00.56	4.1908702
Centennial	211 54 17.38	31 55 36.99	3.7445900
Clinton	224 11 47.70	44 17 52.97	4.2850900
Sherrard	271 04 45.82	91 09 22.42	4.0090858
Riggs Knob	344 41 46.06	164 43 47.81	4.2327314

ELDERS, JEFFERSON COUNTY.

Situated one-half mile south of the village of Monroeville, on land owned by Mr. Elder.

Station mark: A cut marble post 48 by 6 by 6 inches, sunk 40 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey, Ohio."

[Latitude 40° 35′ 40.04″. Longitude 80° 50′ 29.55″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Jefferson	26 13 45.61	206 09 16.01	4.3452306
Carrollton	82 57 51.91	262 50 29.70	4.2070630
Kensington	148 30 40.69	328 26 39.02	4.2218375
Hammond	238 50 48.93	58 57 24.93	4.2224370
Allison	269 43 49.10	89 54 31.77	4.3659427
Wintersville	336 29 21.40	156 33 37.87	4.3682786

HOPEDALE, JEFFERSON COUNTY.

Situated 2 miles west of Bloomingdale, on the north side of the Bloomingdale and Hopedale pike, on the highest point of hill in cleared field belonging to S. N. Beall.

Station mark: A cut marble post 24 by 4 by 4 inches, sunk 24 inches under surface of ground, "U. S. G. S." marked on top of post.

[Latitude 40° 19′ 53.80″. Longitude 80° 51′ 20.65″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Cadiz Court-House	61 46 20.94	241 40 48.88	4.1388232
Cadiz	69 46 06.04	249 40 19.70	4.1295800
Jefferson	137 22 06.82	317 18 11.04	4.1028039
Wintersville	233 31 31.07	53 36 19.99	4.1166735
New Alexander	290 17 09.61	110 23 39.92	4.1817202
Mount Pleasant	345 17 50.68	165 20 26.93	4.3534510

JACOBSBURG, BELMONT COUNTY.

Situated on the top of Mr. Robert McKelvey's house. Signal was placed on roof within railing. The center comes at edge of second layer of tin from south railing and in center of cupola east and west.

[Latitude 39° 58′ 24.01″. Longitude 80° 53′ 04.87″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Beallsville	30 28 36.52	210 24 54.13	4.2108474
Gallaway	119 38 37.92	299 35 16.63	3.9318086
Myers	248 31 07.18	68 34 01.77	3.8405264

ST. CLAIRSVILLE COURT-HOUSE, BELMONT COUNTY.

(Not occupied.)

Station mark: Center of cupola on court-house.

[Latitude 40° 04′ 50.90″. Longitude 80° 54′ 05.72″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Mount Pleasant	237 58 45.00	58 03 07.29	4.0555471
Sherrard	297 53 05.27	118 01 16.04	4.3112543

KENSINGTON, CARROLL COUNTY.

Situated 1 mile south of Kensington on the highest point of a wooded hill. A county road passes over the south side of the hill.

Theodolite elevated 60 feet.

Station mark: A cut marble post 48 by 6 by 6 inches, sunk 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey, Ohio."

[Latitude 40° 43′ 20.61″. Longitude 80° 56′ 40.47″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Carrollton	24 09 27.05	204 06 05.89	4.2491471
Hammond	283 34 21.24	103 44 59.61	4.3739205
Elders	328 26 39.02	148 30 40.69	4.2218375

JEFFERSON, HARRISON COUNTY.

Situated on a bare hill one-fourth mile northwest of the town of Jefferson, between the forks of the New Philadelphia and the Carrollton roads, on land owned by Samuel Meed.

Station mark: A cut marble post 42 by 6 by 6 inches, sunk 36 inches in the ground, in center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey, Ohio."

[Latitude 40° 24′ 55.88″. Longitude 80° 57′ 24.63″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	Meters.
Cadiz	16 08 19.68	196 06 28.74	4.1631951
Carrollton	160 48 24.64	340 45 32.78	4.2772402
Elders	206 09 16.01	26 13 45.61	4.3452306
Wintersville	274 33 35.99	94 42 21.10	4.2824762
Hopedale	317 18 11.04	137 22 06.82	4.1028039

CLARKS HILL, BELMONT COUNTY.

Situated 1 mile east of Bannock station, south of the Cleveland, Lorain and Wheeling Railway, on the summit of a hill owned by the heirs of Mr. Samuel Clark.

Station mark: A cut marble post 6 by 6 inches on top and extending to 6 by 12 inches at bottom. It is 24 inches long, sunk 25 inches in the ground, and set in cement. In the center of the top is cemented a bronze triangulation tablet marked "U. S. Geological Survey, Ohio."

[Latitude 40° 06′ 18.28″. Longitude 80° 57′ 46.47″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	Meters.
Gallaway	4 07 10.89	184 06 50.55	4.0183311
Cadiz	170 13 03.93	350 11 27.43	4.3177623
Mount Pleasant	257 20 13.51	77 26 58.01	4.1827579

GALLAWAY, BELMONT COUNTY.

Situated 4 miles southeast of Belmont and 2 miles south of Lewis Mills, on the summit of a bare hill owned by Mr. Gallaway.

Station mark: A cut marble post 40 by 6 by 6 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey, Ohio."

[Latitude 40° 00′ 40.95″. Longitude 80° 58′ 18.07″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	Meters.
Beallsville	2 29 55.83	182 29 34.33	4.2612655
Clarks Hill	184 06 50.55	4 07 10.89	4.0183311
Mount Pleasant	228 38 05.78	48 45 10.24	4.3180322
Myers	276 53 33.03	96 59 49.03	4.1453970
Jacobsburg	299 35 16.63	119 38 37.92	3.9318086

BEALLSVILLE, MONROE COUNTY.

Situated 3 miles east of the town of Beallsville, on the highest point of a bare hill on the farm of the Gale brothers.

Station mark: A cut marble post 48 by 6 by 6 inches, set 40 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey, Ohio."

[Latitude 39° 50′ 49.78″. Longitude 80° 58′ 51.54″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gallaway	182 29 34.33	2 29 55.83	4.2612655
Jacobsburg	210 24 53.13	30 28 36.52	4.2108474
Myers	221 32 26.97	41 39 03.80	4.3447990
Riggs Knob	269 45 19.11	89 53 56.89	4.2835700

CADIZ COURT-HOUSE, HARRISON COUNTY.

(Not occupied.)

Station mark: Center of cupola on court-house.

[Latitude 40° 16′ 22.39″. Longitude 80° 59′ 54.02″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hopedale	241 40 48.88	61 46 20.94	4.1388232
Mount Pleasant	310 31 40.34	130 39 47.88	4.3715307

CADIZ, HARRISON COUNTY.

Situated 1½ miles north of the town of Cadiz, on a hill locally known as "the Sand Lot," on land owned by Louis Rider, at forks of road to Hanover and Rumley.

Theodolite elevated 52 feet.

Station mark: A cut marble post 48 by 6 by 6 inches, sunk 36 inches in ground, in center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey, Ohio."

[Latitude 40° 17′ 22.36″. Longitude 81° 00′ 15.98″.]

To station	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Jefferson	196 06 28.74	16 08 19.68	4.1631951
Hopedale	249 40 19.70	69 46 06.04	4.1295800
Mount Pleasant	312 57 37.85	133 05 59.66	4.4004381
Clarks Hill	350 11 27.43	170 13 03.92	4.3177623

CARROLLTON, CARROLL COUNTY.

Situated 2½ miles east of the town of Carrollton, on the Scroggsfield road, on land owned by Mr. Campbell.

Station mark: A cut marble post 40 by 6 by 6 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet marked "U. S. Geological Survey, Ohio."

[Latitude 40° 34′ 35.51″. Longitude 81° 01′ 49.27″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Kensington	204 06 05.89	24 09 27.05	4.2491471
Elders	262 50 29.70	82 57 51.91	4.2070630
Jefferson	340 45 32.78	160 48 24.64	4.2772402

Primary Traverse.

One hundred and ten geographic positions in northeastern Ohio were determined by primary traverse during October, November, and December, 1900, by Mr. E. L. McNair, and based upon three stations of the United States Lake Survey—Claridon, Warrensville, and Grafton.

Circuits were completed as follows: I. Southward from Warrensville triangulation station to Hudson; thence to Ravenna; thence by highways northward to Claridon triangulation station. II. Southward from Hudson, located by first traverse, to Akron; westward to Sterling; thence northward to Grafton triangulation station. III. Westward from Sterling to the eighty-second meridian; thence southward to Wooster, eastward to Canton; thence northward, closing on Akron. A spur line was run from Wooster southwestward 4 miles to Millbrook. IV. Southward from Ravenna to Bayard, thence westward to Canton. V. Eastward from Bayard to Kensington triangulation station, which was located through a series of triangles 270 miles in axial length, based upon Maryland Heights, Sugar Loaf stations, and on United States standard datum of the Coast and Geodetic Survey.

The position of Kensington triangulation station, as computed through the traverse from the lake survey stations compared with that computed through the triangulation upon the United States standard datum, shows a discrepency of 23 feet in latitude and 15 feet in longitude, the latter giving a location north and west of the former. As this is a connection between two entirely different systems of triangulation the discrepancy is very small and is partly attributable to station error and partly to errors in the traverse lines and triangulation. This error was distributed in the traverse line between Bayard and Kensington.

Geographic positions between Warrensville triangulation station, United States Lake Survey, and Bedford, via highways.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Warrensville triangulation station	41 28 39.24	81 30 12.88
Randall station, Erie Rwy., about one-fourth mile west of, road crossing near post-office	41 25 42.6	81 32 12.0
Bedford station, Cleveland and Pittsburg Rwy	41 23 24.1	81 32 09.8

Geographic positions along Cleveland and Pittsburg Railway, between Bedford and Kensington.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Macedonia station	41 18 48.3	81 30 37.3
Hudson, Western Reserve Academy Observatory	41 15 37.6	81 26 14.9
Portage and Summit, county line	41 12 45.3	81 23 33.2
Earlville station	41 11 21.0	81 20 42.8
Erie Rwy. crossing	41 10 18.4	81 18 40.7
Ravenna, Main street crossing	41 09 28.0	81 14 52.5
Ravenna, Pittsburg and Western Rwy. crossing	41 08 56.4	81 14 44.6
Rootstown station, road crossing 150 feet north of	41 06 18.4	81 12 52.7
Road crossing 15 feet south of milepost 45	41 04 38.2	81 11 40.5
Road crossing 655 feet north of milepost 48	41 02 21.2	81 10 20.6
Atwater station road crossing 295 feet south of	41 01 25.4	81 09 50.8
Portage and Stark counties, road crossing on county line	40 59 17.4	81 08 41.2
Road crossing 1,695 feet south of milepost 55	40 56 27.5	81 06 57.0
Alliance, Alliance and Northern Rwy. crossing	40 55 33.0	81 06 04.4
Alliance, Pittsburg, Fort Wayne and Chicago crossing	40 55 18.6	81 05 45.0
Alliance station	40 55 17.1	81 05 43.2
Stark and Mahoning counties, road crossing on county line	40 54 44.1	81 05 13.8
Road crossing 1,070 feet north of milepost 61	40 52 20.4	81 04 08.3
Homeworth station, road crossing 55 feet south of	40 50 14.8	81 04 04.4
Moultrie station, road crossing 255 feet south of	40 47 47.8	81 04 14.3
Bayard station	40 45 02.7	81 03 58.4
East Rochester station, road crossing 700 feet east of	40 44 41.8	81 02 06.3
Hanover-West township line	40 44 00.5	80 58 32.2
Kensington station, road crossing 150 feet west of	40 44 05.3	80 57 23.3
Kensington triangulation station	40 43 20.6	80 56 40.5

Geographic positions along Cleveland, Akron and Columbus Railway, Hudson to Akron.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Flag station, road crossing at, 1,770 feet south of milepost 3	41 11 52.4	81 27 53.8
Road crossing 1,370 feet north of milepost 6	41 09 50.3	81 28 10.8
Cuyahoga Falls station	41 08 06.9	81 28 52.0
Road crossing 1,925 feet south of milepost 10	41 06 08.1	81 29 23.0
Cleveland, Terminal and Valley Rwy. crossing, stone arch	41 05 08.5	81 29 24.3
Akron, Union station	41 04 58.7	81 30 34.8
Akron, court-house grounds, south meridian mark	41 04 44.3	81 31 05.0
Akron, court-house grounds, north meridian mark	41 04 47.8	81 31 05.0

Geographic positions along Erie Railway, Akron to Burbank.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Akron, Erie station, 2¼ miles west of, old canal crossing	41 02 46.1	81 32 35.7
Road crossing (Baltimore and Ohio Rwy.), 2,200 feet southwest of milepost 18	41 01 56.4	81 34 52.1
Barberton station	41 01 13.2	81 36 36.5
Sherman station	41 00 50.4	81 40 05.0
Wadsworth station	41 01 02.7	81 43 46.6
Road crossing one-half mile west of milepost 217	40 59 46.5	81 44 55.5
Rittman station	40 58 06.4	81 46 55.2
Sterling: Cleveland, Lorain and Wheeling crossing	40 58 10.9	81 50 52.7
Creston station	40 58 56.6	81 53 33.2
Road crossing 370 feet east of water tank	40 59 22.8	81 57 30.2
Burbank station	40 59 24.2	81 59 50.1
Baltimore and Ohio crossing (Lodi and Wooster branch)	40 59 19.4	82 01 33.7

Geographic positions along Cleveland, Lorain and Wheeling Railway, from Sterling to Grafton triangulation station (United States Lake Survey).

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Sterling, Erie Rwy. crossing	40 58 10.9	81 44 55.5
Seville station	41 00 30.5	81 51 50.5
Road crossing 2,340 feet south of milepost 39	41 02 39.8	81 53 04.0
Flag station 400 feet south of milepost 37	41 04 37.6	81 53 39.8
Road crossing 250 feet north of milepost 34	41 07 16.1	81 53 03.3
Medina station	41 08 18.8	81 52 24.3
Road crossing 2,150 feet south of milepost 29	41 10 01.9	81 55 13.2
Lester station	41 10 48.2	81 56 31.5
Erhart station	41 11 55.2	81 58 21.1
Grafton triangulation station (United States Lake Survey)	41 12 44.21	81 59 37.85

Geographic positions along Lodi and Wooster branch of Baltimore and Ohio Railroad, from Erie crossing to Wooster.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Erie crossing	40 59 19.4	82 01 33.7
Road crossing at flag station	40 57 08.3	82 01 27.7
Armstrong flag station	40 54 42.0	82 00 34.0
Overton flag station	40 51 51.0	82 00 32.3
Road crossing 600 feet south of water tank	40 48 38.1	81 58 51.0
Wooster fair grounds, south meridian mark	40 47 50.3	81 57 03.5
Wooster fair grounds, north meridian mark	40 47 55.6	81 57 03.5
Wooster station, Baltimore and Ohio R. R	40 47 43.6	81 56 55.1

Geographic positions along Pittsburg, Fort Wayne and Chicago Railway, from Millbrook to Orrville.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Bridge 121, northwest corner of, copper bolt in bridge abutment	40 43 59.9	81 58 24.6
Road crossing 100 feet east of bridge 121	40 44 00.7	81 58 23.8
Overhead road crossing	40 44 51.8	81 57 41.4
Baltimore and Ohio overhead crossing	40 46 32.6	81 56 47.7
Wooster station	40 47 57.0	81 55 54.8
Stone arch culvert 1,040 feet north of milepost 132	40 49 09.8	81 53 19.6
Smithville station	40 50 25.5	81 51 40.9
Road crossing about one-third mile east of water tank	40 49 46.0	81 48 35.0
Orrville, Pittsburg, Fort Wayne and Chicago and Cleveland, Akron and Columbus Rwy	40 50 22.1	81 46 05.8

Geographic positions along Wheeling and Lake Erie Railway, between Orrville and Massillon.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Burton City station	40 50 36.5	81 42 12.1
Dalton station	40 48 02.0	81 41 15.2
Pocock mine junction	40 48 20.7	81 38 43.9
Sippo station, road crossing 325 feet west of	40 48 56.4	81 36 05.9
Sherwood flag station, road crossing at	40 48 19.8	81 33 17.9
Massillon, crossing of Wheeling and Lake Erie and Cleveland, Lorain and Wheeling Rwys	40 47 43.5	81 31 47.3

Geographic positions along Pittsburg, Fort Wayne and Chicago Railway, between Massillon and Canton.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Massillon, East street crossing	40 47 32.4	81 31 01.2
Road crossing 2,150 feet east of milepost 107	40 47 11.6	81 27 57.6
Road crossing 700 feet west of milepost 104	40 46 54.1	81 25 11.8
Canton, Pittsburg, Fort Wayne and Chicago Rwy. and Cleveland Terminal and Valley Rwy. crossing	40 47 24.2	81 23 02.1

Geographic positions along the Cleveland Terminal and Valley Railway, between Canton and Akron.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Canton station	40 48 01.5	81 23 16.1
Road crossing 1,525 feet south of milepost 54	40 51 16.8	81 24 49.2
New Berlin station, road crossing 65 feet north of	40 52 54.0	81 25 32.3
Greentown station, road crossing 245 feet north of	40 55 42.5	81 25 10.8
Myersville station, road crossing 215 feet north of	40 58 34.0	81 25 36.7
Road crossing 280 feet north of milepost 44	40 59 41.9	81 26 44.5
Krumroy station, road crossing 225 feet south of	41 00 55.8	81 28 42.8
Overhead road crossing 425 feet south of milepost 39	41 03 07.2	81 28 37.0

Geographic positions along Wheeling and Lake Erie Railway, between Canton and Minerva.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Canton, crossing of Pittsburg, Fort Wayne and Chicago Rwy	40 47 43.3	81 22 07.3
Road crossing 1,826 feet west of milepost 63	40 46 26.4	81 19 17.9
Osnaburg station road crossing, 425 feet east of	40 47 03.7	81 16 59.6
Road crossing 1,650 feet east of milepost 67	40 45 58.0	81 14 51.9
Robertsville station, road crossing 90 feet west of	40 45 38.9	81 11 21.6
Road crossing 180 feet south of milepost 73	40 44 54.2	81 09 24.0
Road crossing 450 feet south of milepost 75	40 43 09.5	81 09 11.8
Minerva, crossing of Cleveland and Pittsburg Rwy. (new Philadelphia branch) along Cleveland and Pittsburg Rwy	40 43 31.5	81 06 26.2
Minerva station, Cleveland and Pittsburg Rwy., road crossing, about 2,200 feet northeast of	40 43 40.3	81 06 09.9

Geographic positions along highway from Ravenna northward to Claridon triangulation station (United States Lake Survey).

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Shalersville, 2½ miles south of, 4 corners	41 12 07.4	81 14 47.1
Shalersville, intersection of roads at	41 14 19.8	81 13 53.6
Mantua station, Erie Railway crossing near	41 16 52.8	81 13 28.8
Mantua post-office, road intersection at	41 18 37.3	81 13 19.2
Julia post-office, county line between Portage and Geauga County	41 20 50.8	81 13 27.3
Auburn, road intersection at store	41 23 14.0	81 13 00.2
South Newbury post-office, 2,000 feet south of, and ½ mile south of creamery, electric railway crossing	41 25 58.4	81 12 32.9
Burton, 2¾ miles southeast of, 4 corners	41 26 59.7	81 10 53.4
Burton, street intersection, north side of park	41 28 21.4	81 08 43.9
Burton, about 1¾ miles north of, 4 corners	41 29 49.5	81 08 43.8
Claridon triangulation station (U. S. Lake Survey)	41 30 39.61	81 07 06.27

Meridian Marks.

CANTON, STARK COUNTY, OHIO.

Location of station: On the Stark County fair grounds at Canton. Station mark: A marble post 40 by 6 by 8 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze meridian *tablet. It* is 25 feet north of inside fence at south end of race track.

Reference mark: Center of judges' stand, 390.6 feet distant; true azimuth, 148° 01′ 30″.

Distant mark: A marble post 40 by 6 by 8 inches, set 36 inches in the ground, in the center of top of which is a bronze meridian tablet. It is 765 feet north of the station mark and 283 feet south of inside fence at north end of race track.

Center of judges' stand, 480½ feet distant; true azimuth, 25° 30′ 00″.

Resident referee: Mr. John S. Hoover, county surveyor.

ST. CLAIRSVILLE, BELMONT COUNTY, OHIO.

Location of station: Within the Belmont County Agricultural Society fair grounds.

Station mark: A sandstone post 40 by 12 by 20 inches set 40 inches in the ground, in the center of top of which is cemented a bronze meridian tablet.

Distant mark: North of station 400 feet, a sandstone post 72 by 12 by 20 inches set 40 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

WOOSTER, WAYNE COUNTY, OHIO.

Location of station: On the Wayne County fair grounds.

Station mark: A marble post 36 by 6 by 9 inches set 34 inches in the ground, in the center of top of which is cemented a bronze meridian tablet.

Reference marks: Center of judges' stand, 129 feet distant; true azimuth, 181° 31′; tree, 426 feet distant; azimuth, 104° 00′.

Distant mark: 539.4 feet north of station mark, 40 feet from inside edge of race track, a marble post 36 by 6 by 9 inches set 34 inches in the ground, in the center of top of which is cemented a bronze meridian tablet.

Reference marks: Center of judges' stand, 413 feet distant; true azimuth, 356° 25′; tree, 601 feet distant; azimuth, 43° 25′.

Resident referee: County surveyor.

NORTH CAROLINA.

Primary Traverse.

The following geographic positions were determined by primary railroad traverse by Mr. Oscar Jones, assistant topographer, in September and October, 1900. The line begins at the Episcopal Church spire at Newbern (located by the United States Coast and Geodetic Survey), and follows the Atlantic and North Carolina Railroad to Goldsboro; thence along the Atlantic Coast Line Railroad via Rockymount and Parmele to Washington, connecting with Cedar Grove triangulation station of the United States Coast and Geodetic Survey. A spur line was run from Parmele to Plymouth.

Geographic positions along Atlantic and North Carolina Railroad between Newbern and Goldsboro.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Newbern, Episcopal Church spire, United States Coast and Geodetic Survey	35 06 25.04	77 02 21.98
Newbern, national pike crossing	35 07 01.0	77 02 47.7
Road crossing 1,470 feet east of milepost 40	35 07 45.9	77 05 44.1
Clark post-office and sawmill, road crossing at	35 08 44.8	77 09 35.5
Tuscarora station	35 09 34.1	77 12 49.5
Road crossing 2,190 feet east of milepost 51	35 10 34.1	77 16 46.0
Coar Creek station	35 11 11.7	77 19 14.3
Road crossing 2,306 feet east of milepost 56	35 11 50.8	77 21 48.8
Road crossing 1,140 feet west of milepost 58	35 12 31.5	77 24 30.1
Dover station	35 12 57.5	77 26 12.9
Road crossing 1,470 feet west of milepost 64	35 14 00.9	77 30 40.4
Neuse River bridge, east end of	35 14 36.5	77 33 27.0
Kinston, crossing of Atlantic Coast Line Rwy	35 15 31.5	77 34 27.1
Kinston station	35 15 51.4	77 34 53.7
Road crossing 1,480 feet west of milepost 72	35 16 15.8	77 38 12.4
Falling Creek station	35 16 34.8	77 41 22.6
Road crossing 285 feet east of milepost 78	35 17 08.6	77 44 05.8
Lagrange station	35 18 25.7	77 47 17.3
Beston station	35 20 37.0	77 50 49.7
Road crossing 1,080 feet west of milepost 88	35 21 38.6	77 52 59.4
Road crossing 160 feet west of milepost 91	35 22 47.0	77 55 59.6
Goldsboro, junction with Atlantic Coast Line Rwy	35 23 27.9	77 59 34.8
Goldsboro, north meridian mark	35 22 53.4	77 59 37.2
Goldsboro, south meridian mark	35 22 51.7	77 59 37.2

Geographic positions along Atlantic Coast Line Railway, between Goldsboro and Rockymount.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Road crossing 160 feet north of milepost 87	35 25 30.0	77 58 58.8
Road crossing 360 feet south of milepost 90	35 28 02.3	77 58 58.2
Pikeville station	35 29 52.6	77 58 57.7
Water tank 580 feet north of milepost 93	35 30 50.5	77 58 57.4
Road crossing 180 feet north of milepost 94	35 31 38.2	77 58 56.4
Fremont station	35 32 41.8	77 58 25.8
Road crossing 1,510 feet south of milepost 99	35 35 24.6	77 57 01.5
Blackcreek station	35 38 14.2	77 55 56.5
Contentnea station, junction main line	35 40 42.8	77 55 51.0
Wilson station	35 43 21.9	77 54 24.5
Road crossing 860 feet north of milepost 110	35 44 47.9	77 53 37.7
Road crossing 20 feet south of milepost 113	35 47 03.2	77 52 24.6
Elm City station	35 48 21.4	77 51 42.4
Road crossing 1,000 feet south of milepost 116	35 49 17.1	77 51 11.8
Sharpsburg	35 52 01.0	77 49 43.8
Road crossing 1,790 feet south of milepost 121	35 53 10.9	77 49 08.4
South Rockymount, main line junction	35 55 51.7	77 48 02.5
Rockymount station	35 56 18.5	77 47 51.7

Geographic positions along Atlantic Coast Line Railway, Rockymount east to Plymouth.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Road crossing 15 feet east of milepost 3	35 55 29.1	77 44 58.0
Road crossing 1,495 feet east of milepost 5	35 55 16.8	77 42 30.6
Kinsboro station	35 55 05.6	77 40 14.0
Hartsboro station	35 54 58.3	77 38 44.8
Road crossing 696 feet west of milepost 12	35 54 42.6	77 35 31.8
Tarboro, main-line junction	35 54 28.9	77 32 47.2
Tarboro station	35 54 28.6	77 32 33.0
Tar River bridge, west end of	35 53 35.2	77 32 07.2
Mildred station	35 50 53.8	77 29 29.4
Conetoe station	35 48 56.5	77 27 19.7
Road crossing 840 feet west of milepost 25	35 48 03.7	77 25 15.7
Bethel station	35 48 28.7	77 22 31.7
Parmele, railroad crossing at	35 48 58.4	77 18 50.8
Robersonville station	35 49 27.5	77 15 10.9
Everetts station	35 50 05.6	77 10 23.1
Williamston, junction of spur track to station	35 50 57.1	77 03 51.6
Williamston, road crossing at	35 50 48.0	77 03 35.2

Geographic positions along Atlantic Coast Line Railway, Rockymount east to Plymouth—Continued.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Water tank 760 feet west of milepost 48	35 49 18.1	77 02 40.6
Road crossing 990 feet east of milepost 51	35 48 35.8	76 59 14.6
Jamesville, tram road crossing 1 mile west of	35 48 38.6	76 54 41.1
Jamesville station	35 48 21.0	76 53 48.7
Road crossing 510 feet east of milepost 60	35 48 46.6	76 49 40.5
Road crossing 2,610 feet east of milepost 63	35 50 38.0	76 47 25.8
Plymouth, tram road crossing west of	35 51 08.8	76 45 45.0
Plymouth station	35 52 10.0	76 44 52.4
Plymouth, river front, first cross street	35 52 07.2	76 44 54.8
Plymouth, river front, last cross street	35 51 59.0	76 45 14.6
Plymouth, north meridian mark	35 51 41.9	76 45 14.1
Plymouth, south meridian mark	35 51 38.1	76 45 14.1

Geographic positions along the Atlantic Coast Line Railway from Washington to Parmele.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Cedar Grove triangulation station, United States Coast and Geodetic Survey	35 31 52.6	77 02 11.0
Washington station	35 32 43.2	77 03 27.2
Wharton station	35 35 48.9	77 07 19.2
Pactolus station	35 37 41.4	77 13 02.5
Whichard, tramroad crossing east of	35 41 43.3	77 15 13.5
Whichard station	35 41 49.3	77 15 16.6
Williams station	35 45 28.5	77 17 15.1

Geographic positions along Atlantic Coast Line Railway from Parmele to Kinston.

Stations.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Grindool station	35 45 57.0	77 19 57.2
Sawmill, road crossing at	35 41 18.3	77 21 17.2
House station	35 39 15.5	77 21 52.6
Greenville station	35 36 25.2	77 22 48.5
Parksville station	35 33 40.1	77 23 20.8
Winterville station	35 31 44.2	77 24 07.0
Ayden station	35 28 20.4	77 24 58.0
Flag station 1,300 feet north of milepost 72	35 24 25.8	77 25 36.2
Grifton station	35 22 20.5	77 26 17.8
Graingers station	35 19 11.8	77 30 32.0

SOUTH CAROLINA.

Primary Traverse.

A line of primary railroad traverse was run by Mr. S. Tatum, topographer, in 1900 from the Columbia State capitol (located by astronomic methods by the United States Coast and Geodetic Survey) along the Southern Railway to Spartanburg, connecting with the dome of St. Johns College, located by triangulation from the oblique arc of the United States Coast and Geodetic Survey. A circuit was completed by running from Carlisle, of the former line, eastward along the Seaboard Air Line Railway to Chester; thence southward along the Southern Railway to Columbia. Another circuit was completed by running westward from Columbia along the Southern Railway to Leesville; thence northward via highways to Prosperity; thence eastward along the Southern Railway, connecting with the first line at Alston.

Meridian lines were established at Chester, Columbia, Lexington, Union, and Winnsboro.

Geographic positions along Southern Railway from Columbia to Spartanburg.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Columbia. State capitol dome, United States Coast and Geodetic Survey astronomic position	33 59 56.8	81 02 02.7
Road crossing (near river bridge)	34 01 31.9	81 03 53.6
Milepost 7	34 05 08.1	81 05 36.2
Milepost 11	34 07 50.9	81 07 57.2
Bookman flag station, road crossing at	34 09 44.4	81 09 14.8
Littleton flag station	34 10 42.0	81 10 39.4
Milepost 19	34 12 32.4	81 13 42.3
Wallaceville flag station	34 12 34.4	81 15 05.9
Alston station	34 14 34.7	81 18 59.2
Road crossing 2,885 feet north of milepost 133	34 16 51.9	81 20 17.3
Milepost 131	34 18 04.5	81 20 32.9
Dawkins station	34 21 18.8	81 22 04.8
Road crossing 3,050 feet north of milepost 125	34 22 53.7	81 22 49.0
Strother station	34 23 34.2	81 23 39.8
Blair flag station	34 25 03.6	81 24 10.4
Beaver Creek, center of stream	34 26 25.4	81 24 28.5
Lyles Ford	34 27 06.3	81 25 01.3
Milepost 117	34 28 55.4	81 25 05.3
Shelton station	34 29 48.7	81 25 10.1
Milepost No. 113	34 32 13.5	81 26 07.6
Road crossing 383 feet south of milepost 111	34 33 50.4	81 26 43.4

Geographic positions along Southern Railway from Columbia to Spartanburg—Continued.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Carlisle station	34 35 31.2	81 27 54.6
Road crossing 1,330 feet north of milepost 107	34 36 52.7	81 29 20.0
Santuck station	34 38 00.8	81 31 07.8
Road crossing 215 feet south of milepost 103	34 39 09.2	81 31 48.7
Road crossing 2,318 feet south of milepost 101	34 40 19.2	81 32 41.8
Road crossing 245 feet south of milepost 100	34 41 11.1	81 33 37.4
Milepost 97	34 42 56.2	81 35 49.0
Union station	34 42 55.8	81 37 12.3
Milepost 94	34 44 10.9	81 37 58.0
Road crossing 2,360 feet south of milepost 93	34 45 20.8	81 37 43.4
Road crossing 1,270 feet south of milepost 90	34 47 08.4	81 38 36.4
Lockhart Junction	34 49 06.5	81 39 01.8
Jonesville station	34 50 07.0	81 40 42.1
Road crossing 4,255 feet south of milepost 83	34 51 14.8	81 42 12.2
Road crossing 200 feet north of milepost 82	34 51 53.9	81 43 44.1
Pacolet station	34 53 53.7	81 45 34.9
Milepost 77	34 54 23.4	81 47 31.0
Rich Hill flag station	34 54 11.8	81 48 59.7
Road crossing 1,265 feet north of milepost 74	34 55 01.5	81 50 34.1
Glendale station	34 55 24.1	81 51 38.5
Spartanburg, dome of St. John's College, United States Coast and Geodetic Survey position	34 57 17.2	81 54 55.6

Geographic positions along Seaboard Air Line Railway from Carlisle to Chester.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Carlisle, crossing of Seaboard Air Line Rwy. and Southern Rwy	34 35 27.3	81 27 50.8
Broad River, right bank	34 37 21.6	81 25 01.4
Leeds station	34 37 48.8	81 23 40.7
Milepost 54	34 38 41.7	81 20 42.4
Milepost 53	34 39 11.5	81 19 52.4
Milepost 51	34 39 44.6	81 18 05.2
Road crossing 1,955 feet east of milepost 50	34 40 06.4	81 16 46.2
Road crossing	34 42 12.1	81 14 20.2
Chester station, Seaboard Air Line Rwy	34 42 30.2	81 12 57.8

Geographic positions along Southern Railway from Chester to Columbia.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Chester station, Southern Rwy	34	42	16.9	81	12	14.5
Road crossing 1,017 feet north of milepost 46	34	41	09.1	81	11	28.3
Milepost 48	34	39	22.3	81	11	42.6
Road crossing (bridge overhead)	34	38	41.9	81	11	10.3
Cornwall station	34	36	23.4	81	10	42.7
Milepost 54	34	34	40.2	81	10	20.8
Blackstock station	34	33	29.3	81	09	10.1
Woodward station	34	31	33.7	81	10	14.1
Road crossing 270 feet south of milepost 59	34	31	12.0	81	09	44.3
Road crossing 700 feet south of milepost 61	34	29	51.1	81	08	27.8
Whiteoak station	34	28	19.5	81	07	04.6
Milepost 65	34	27	03.7	81	07	14.4
Adgers station	34	25	59.0	81	07	27.1
Road crossing 550 feet north of milepost 69	34	24	38.3	81	05	41.9
Winnsboro station	34	22	33.8	81	05	04.0
Milepost 73	34	21	20.8	81	04	52.4
Rockton station	34	20	24.7	81	04	46.4
Milepost 77	34	18	49.6	81	02	57.6
Simpson station	34	18	33.9	81	02	48.9
Milepost 80	34	18	38.4	81	00	22.0
Ridgeway station	34	18	18.9	80	57	39.5
Milepost 84	34	17	31.5	80	57	05.3
Campbells flag station	34	16	52.4	80	56	59.0
Milepost 87	34	15	13.6	80	57	32.2
Blythewood station	34	12	52.7	80	58	24.5
Milepost 93	34	10	33.5	80	57	16.4
Killian station	34	08	12.8	80	56	48.5
Milepost 97	34	07	16.7	80	56	45.8
Road crossing 815 feet north of milepost 98	34	06	44.2	80	56	50.4
Milepost 99	34	05	48.6	80	57	36.8
Dents flag station	34	05	08.2	80	58	27.7
Road crossing 3,475 feet south of milepost 101	34	03	58.6	80	58	58.8
Crossing of Seaboard Air Line	34	03	16.2	81	00	10.2
Milepost 104	34	02	34.2	81	00	38.6
Columbia, Blanding street station	34	00	39.2	81	01	29.0
Columbia, East Capitol street crossing	33	59	21.5	81	01	46.8

Geographic positions along Southern Railway from Columbia to Leesville.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Broad River, east bank	33 58 35.0	81 02 48.1
Cayce station	33 58 22.6	81 03 19.8
Road crossing 250 feet west of milepost 114	33 58 33.2	81 07 15.7
Arthur station	33 58 11.2	81 08 48.3
Milepost 119	33 58 17.5	81 12 17.6
Lexington station	33 57 58.3	81 14 05.2
Barrs station	33 56 17.5	81 17 36.4
Shumpert station	33 55 50.6	81 20 05.2
Milepost 129	33 55 25.4	81 21 24.7
Gilbert station	33 55 24.7	81 23 37.6
Summit station	33 55 24.7	81 25 20.6
Fredonia station	33 55 33.6	81 27 44.4
Leesville station	33 54 59.9	81 30 46.5

Geographic positions along highway from Leesville to Prosperity.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Crossing of Hollow Creek	33 56 59.1	81 32 02.4
Delmar post-office, road crossing 2 miles south of	33 59 14.7	81 31 19.8
Delmar post-office	34 00 38.0	81 30 41.3
Delmar post-office, 1½ miles north of, crossing of roads	34 01 29.4	81 29 51.9
Dupler post-office	34 03 00.1	81 29 42.9
Baptist Church	34 03 30.6	81 29 50.0
Saluda River, south bank	34 04 45.1	81 29 07.0
Upwell	34 05 22.6	81 28 48.1
Oneal School	34 07 00.7	81 30 14.6
Prosperity, 3 miles south of, road forks	34 10 27.5	81 32 07.1
Prosperity, 2 miles south of, road crossing (Columbia road)	34 10 48.4	81 31 56.2

Geographic positions along Southern Railway from Prosperity to Alston.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Prosperity, crossing Southern Rwy. and street	34 12 30.8	81 32 57.4
Road crossing 1,025 feet west of milepost 39	34 12 34.3	81 31 27.6
Road crossing 1,992 feet west of milepost 37	34 12 59.2	81 29 38.4
Road crossing 1,920 feet west of milepost 36	34 13 08.9	81 28 36.5
Road crossing, overhead bridge	34 13 49.2	81 26 56.3
Pomaria station	34 15 43.0	81 24 47.8
Road crossing 2,125 feet east of milepost 29	34 15 43.4	81 22 05.2
Road crossing 2,905 feet east of milepost 27	34 14 41.2	81 20 19.4
Road crossing 297 feet west of milepost 26	34 14 29.0	81 20 02.0
Peaks station	34 14 29.2	81 19 22.4
Alston station	34 14 34.7	81 18 59.2

Meridian Marks.

CHESTER, CHESTER COUNTY.

Location of station: In city park, just east of summit house, on top of knoll.

Station mark: A marble post 48 by 8 by 8 inches, set 46 inches in the ground, in the center of top of which is cemented a bronze tablet.

Distant mark: North of station 458 feet, a marble post 48 by 8 by 8 inches, set 46 inches in the ground, in center of top of which is cemented a bronze tablet.

Local reference: James Hamilton, jr., city engineer.

COLUMBIA, RICHLAND COUNTY.

Location of station: In State College park, east of college building and just north of street forming southern boundary of park.

Station mark: A marble post 48 by 6 by 6 inches, set 46 inches in the ground, in the center of top of which is cemented a bronze tablet.

Distant mark: North of station, a marble post 48 by 8 by 8 inches, set 46 inches in the ground, in top of which is cemented a bronze tablet.

Local referee: Professor Colcock.

LEXINGTON, LEXINGTON COUNTY.

Location of station: In city park, near southeast corner, about 10 feet north of south side.

Station mark: A granite post 48 by 10 by 10 inches, set 46 inches in the ground, with bronze tablet cemented in top.

Distant mark: A granite post 48 by 10 by 10 inches, set 46 inches in ground, 360.5 feet distant, in northeast corner of city cemetery.

UNION, UNION COUNTY.

Location of station: In grounds surrounding Union High School, west of high-school building and north of street forming southern boundary of grounds.

Station mark: A marble post 42 by 8 by 8 inches, set 40 inches in the ground, in the center of top of which is cemented a bronze tablet.

Distant mark: North of station 371 feet, near northern boundary of high-school grounds, a marble post 42 by 8 by 8 inches, set 40 inches in the ground, in the center of top of which is cemented a bronze tablet.

Resident referee: Colonel Young.

WINNSBORO, FAIRFIELD COUNTY.

Location of station: In park in front of Winnsboro College, about 200 feet west of east side of park and 5 feet north of south side of

Station mark: A granite post 48 by 8 by 8 inches, set 46 inches in the ground, with bronze tablet cemented in top.

Distant mark: North of station 348 feet, a granite post 48 by 8 by 8 inches, set 46 inches in ground.

Local referee: President Winnsboro College.

CENTRAL SECTION OF TOPOGRAPHY.

OHIO.

Primary Traverse.

The following geographic positions were determined from primary traverse in 1900 by Mr. George T. Hawkins, topographer.

Starting from United States Coast and Geodetic Survey astronomic pier at Mount Lookout, Cincinnati, the line follows the Baltimore and Ohio Southwestern and Baltimore and Ohio railroads to Columbus, Ohio; thence along the Hocking Valley Railroad to Toledo, Ohio, where it was tied to St. Mary's Church spire (United States Lake Survey station); thence back to Columbus, following line of Toledo and Ohio Central Railway, and connected with original line. Meridian lines were established at Bowling Green, Delaware, Findlay, Kenton, Marysville, Upper Sandusky, and Washington Court-House.

Geographic positions along Baltimore and Ohio Southwestern and Baltimore and Ohio railroads from Cincinnati to Columbus.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Cincinnati, Mount Lookout astronomic pier	39 08 21.93	84 25 21.52
Madisonville station	39 09 26.0	84 23 49.0
East Madisonville station	39 09 35.3	84 23 10.0
Madeira station	39 11 17.0	84 21 45.9
Allandale station	39 11 49.2	84 20 34.4
Remington station	39 13 35.8	84 19 26.7
Symmes station	39 14 50.0	84 17 45.8
Camp Ground station	39 15 18.2	84 16 47.5
Loveland, crossing of Pennsylvania and Baltimore and Ohio Southwestern railways	39 16 00.6	84 15 31.9
Hills station, crossing 340 feet west of	39 15 18.7	84 11 17.7
Cozaddale station, crossing 80 feet west of	39 16 15.2	84 09 39.9
Pleasant Plain station, crossing 110 feet west of	39 16 47.5	84 06 43.6
Windsor station, crossing 30 feet west of	39 17 04.6	84 02 59.5
Blanchester station, crossing 320 feet east of	39 17 31.4	83 59 14.2
Midland station, crossing 310 feet west of	39 18 13.7	83 54 35.4
Midland station	39 18 14.4	83 54 31.5
Cuba station, crossing under railway 200 feet south of	39 21 41.0	83 51 58.1

Geographic positions along Baltimore and Ohio Southwestern and Baltimore and Ohio railroads from Cincinnati to Columbus—Continued.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Milepost 52, crossing 450 feet north of	39	23	59.4	83	51	17.8
Wilmington, Baltimore and Ohio station at	39	26	36.6	83	49	25.2
Blind siding, crossing 450 feet west of head block at	39	27	56.2	83	45	05.3
Melvin station, crossing 200 feet east of	89	28	24.8	83	43	01.2
Reesville, crossing at	39	28	57.1	83	40	41.2
Sabina station, crossing 100 feet west of	39	29	33.6	83	38	07.4
Milepost 69, crossing 800 feet west of	39	30	12.2	83	35	19.4
Rattlesnake, crossing over railroad at	39	30	41.8	83	33	09.4
Jasper Mills, crossing at	39	31	08.0	83	31	14.4
Washington Court-House, south azimuth stone 1,400 feet southward from Baltimore and Ohio station, near coal chutes 6 feet east of main track, 11 feet from end of bulkhead leading to elevated tracks. A limestone post, 36 by 8 by 8 inches, set 33 inches in the ground, in the center of top of which is cemented a bronze meridian tablet. Distant mark is a copper bolt cemented in east abutment of wagon bridge. Azimuth 218° 12′ 45″. Distance from south stone 1,093 feet	39	32	04.0	83	26	53.7
Washington Court-House, crossing of Baltimore and Ohio and Cincinnati, Hamilton and Dayton railways	39	32	13.3	83	26	43.4
Fayette station	39	34	09.9	83	25	13.7
Bloomingburg station, crossing 300 feet east of	39	36	22.7	83	23	17.4
Madison Mills station, crossing 30 feet east of	39	39	13.5	83	20	21.4
Cook station, crossing 200 feet east of	39	40	59.4	83	18	24.3
Mount Sterling station, 300 feet east of Main street crossing	39	43	17.6	83	16	03.7
Era station, crossing 430 feet west of	39	44	23.2	83	14	38.1
Derby station, crossing 350 feet west of	39	46	08.4	83	12	20.5
Morgan station, crossing 100 feet west of	39	48	17.8	83	09	19.5
Pleasant Corners station, crossing 100 feet southwest of	39	50	37.5	83	07	41.1
Grove City station, crossing 100 feet southwest of	39	52	59.7	83	05	44.3
Urbancrest station, crossing 100 feet northeast of	39	53	53.2	83	05	00.4
Briggsdale station, crossing 50 feet northeast of	39	55	36.0	83	03	36.1
United States Geological Survey triangulation station, north base	39	55	57.3	83	03	18.6
Columbus, crossing Baltimore and Ohio Railway and Broad street	39	57	31.9	83	01	54.4

Positions along Hocking Valley Railway from Columbus to Toledo.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Crossing Hocking Valley Railway and pike road east and west	39 59 16.8	83 01 37.1
Columbus, Lane avenue station, crossing 150 feet south of	40 00 24.3	83 01 55.5
Olentangy station, crossing under railway 550 feet north of	40 03 48.5	83 02 48.1
Elmwood station, crossing 200 feet south of	40 05 25.2	83 03 09.4
Milepost 113, crossing 850 feet north of	40 07 01.8	83 03 30.7
Powell station, crossing 160 feet south of	40 09 29.6	83 04 42.3
Milepost 107, crossing 170 feet south of	40 11 44.5	83 05 22.7
Hyatts station, crossing 1,200 feet south of	40 12 58.3	83 05 17.6
Milepost 103, crossing 340 feet south of	40 15 12.6	83 05 08.5
Crossing telephone line	40 17 18.3	83 04 59.8
Delaware, south azimuth stone, 30 feet southeast of "Big Four" and Hocking Valley railways. A limestone post, 28 by 6 by 6 inches, set 28 inches in the ground, in the center of top of which is cemented a bronze meridian tablet. Azimuth 185° 10′	40 17 34.5	83 04 58.4
Delaware, north azimuth stone, 105 feet north of center of street and 72 feet east of railroad. A limestone post, 36 by 6 by 6 inches, set 30 inches in the ground; in center of top is cemented a copper bolt. Azimuth 5° 10′	40 17 47.0	83 04 56.9
Delaware station, crossing 50 feet north of	40 17 58.7	83 04 57.4
Siding, crossing 150 feet south of south end of	40 20 00.3	83 06 03.3
Milepost 95, crossing 200 feet north of	40 21 51.6	83 07 15.9
Radnor station, crossing 160 feet north of	40 23 09.6	83 08 06.0
Mileposts 90 and 91, crossing halfway between	40 25 22.7	83 09 39.1
Prospect station, crossing at	40 27 06.1	83 10 45.7
Crossing, four corners	40 29 28.0	83 09 59.3
Owen station, crossing 600 feet north of	40 31 13.2	83 09 28.6
Mileposts 79 and 80, crossing halfway between	40 34 31.3	83 08 30.8
Marion station, 140 feet south of Main street crossing	40 35 19.2	83 08 28.0
Marion, south azimuth stone, 225 feet north of "Big Four" crossing and 45 feet north of tool house, between Y tracks and main line of Hocking Valley Railway. A limestone post, 40 by 7 by 6 inches, set 40 inches in the ground, in the center of top of which is cemented a bronze meridian tablet. Distant mark is spire of Catholic Church. Azimuth of *same* is 259° 11′ 30″	40 35 25.0	83 08 30.1
Crossing under railroad	40 38 01.5	83 10 25.1

Positions along Hocking Valley Railway from Columbus to Toledo—Continued.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Morral station, crossing 160 feet north of	40 41 12.4	83 12 45.6
T. 3 S., R. 14 E., ¼ corner between secs. 33 and 34	40 44 17.6	83 14 44.8
Harpster station	40 44 20.4	83 15 04.2
Milepost 63, crossing 1,180 feet north of	40 47 19.8	83 17 12.1
Upper Sandusky, south azimuth stone, 9 feet east of railway and 1,395 feet distant from north stone. A limestone post, 30 by 5 by 5 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze meridian tablet. Azimuth 180° 18′ 30″	40 49 14.8	83 17 31.4
Upper Sandusky, north azimuth stone 55 feet south and 150 feet east of crossing of Pittsburg, Fort Wayne and Chicago Railway and Hocking Valley Railway, 11 feet east of Hocking Valley Railway. A limestone post 38 by 6 by 6 inches, set 34 inches in the ground, in center of top is cemented a copper bolt	40 49 28.6	83 17 31.3
Upper Sandusky station	40 49 30.0	83 17 31.3
T. 2 S., R. 14 E., west corner of secs. 19 and 30	40 50 49.7	83 18 16.6
Crossing at flag station	40 53 26.8	83 19 54.7
Crawford station, crossing at	40 55 05.2	83 21 03.8
Carey station, crossing south of	40 57 04.2	83 22 28.3
Carey, south azimuth stone. A copper bolt sunk and cemented in south abutment of bridge north of station, on second stone and 4 feet east of east rail. Azimuth 151° 40′ 20″ to north mark	40 57 10.3	83 22 32.6
Carey, north azimuth stone, 339 feet north of "Big Four" crossing, 8 feet southeast of Northern Ohio crossing and 3½ feet east of east rail on Hocking Valley Railway. A marble post 24 by 8 by 8 inches, set 24 inches in the ground, in center of top is cemented a copper bolt	40 57 22.9	83 22 41.5
¼ corner north of sec. 5 on base line, range 13 E.	40 59 31.7	83 23 49.1
Milepost 45, crossing 900 feet north of	41 01 43.4	83 24 16.0
Alvada station, crossing 100 feet north of	41 03 00.7	83 24 24.1
Siding, crossing 190 feet south of south end of	41 05 38.5	83 24 23.1
Crossing of telephone line	41 07 23.2	83 24 24.0
Fostoria, south azimuth stone, 7 feet east of east rail on Hocking Valley Railway, in arch culvert east of Fostoria Bulb and Bottle Co.'s Works. A bronze meridian tablet cemented in culvert. Azimuth, 179° 35′ 25″	41 08 38.8	83 24 24.6

Positions along Hocking Valley Railway from Columbus to Toledo—Continued.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Fostoria, north azimuth stone, 500 feet south of Baltimore and Ohio and Hocking Valley crossing, and 7 feet east of east rail of Hocking Valley Railway. A sandstone post 36 by 8 by 8 inches, set 34 inches in the ground, in the center of top is cemented a copper bolt	41 09 01.2	83 24 24.8
Fostoria, Hocking Valley Railway, and Toledo and Ohio Central Railway, and street-car crossing	41 09 13.0	83 24 25.6
Fostoria station, Hocking Valley Railway	41 09 40.7	83 24 37.1
Milepost 33, crossing 1,300 feet north of	41 12 11.9	83 25 02.2
Longley station, crossing 320 feet north of	41 13 20.6	83 25 14.3
T. 3 N., Rs. 12 and 13 E., cor. secs. 7, 18, 13, 12	41 13 29.6	83 25 13.7
Risingsun station, crossing 130 feet south of	41 16 06.8	83 25 43.4
T. 4 N., R. 12 E., corner secs. 11, 12, 13, and 14	41 18 43.5	83 26 14.6
Bradner station, crossing 150 feet north of	41 19 22.6	83 26 17.8
Milepost 21, crossing 840 feet south of	41 22 12.1	83 26 47.5
Pemberville station, crossing 80 feet north of	41 24 28.6	83 27 11.3
T. 5 N., R. 12 E., corner secs. 2, 3, 10, 11	41 24 49.6	83 27 16.7
Milepost 16, crossing 480 feet south of	41 26 33.2	83 27 39.9
Lemoyne station	41 29 39.6	83 28 25.7
Pike crossing	41 29 45.2	83 28 27.0

Positions along the Toledo and Ohio Central Railway between Toledo and Columbus.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Lime City, crossing of telephone line road at	41 32 06.2	83 34 01.8
Crossing of telephone line road	41 29 50.4	83 35 15.5
Dowling station, crossing 250 feet north of	41 28 40.4	83 35 53.6
Dowling, 1¼ miles southeast of, corner secs. 20, 21, 28, 29	41 27 27.8	83 36 35.4
Telephone line road	41 25 13.3	83 37 46.2
Bowling Green station, 200 feet north of, telephone road crossing	41 22 33.2	83 38 40.8
Corner Ts. 4 and 5 N., Rs. 10 and 11 E	41 20 31.3	83 39 02.4
Portage station, crossing 150 feet south of	41 19 35.9	83 38 44.8
Mermill station, crossing 200 feet north of	41 17 51.0	83 38 44.3
Corner Ts. 3 and 4 N., Rs. 10 and 11 E	41 15 14.0	83 39 00.6
Cygnet station, crossing 270 feet north of	41 14 23.5	83 38 43.3
Milepost 32, crossing at	41 12 40.0	83 38 42.8
West corner secs. 30 and 31, T. 3 N., R. 11 E	41 10 55.8	83 38 57.6

Positions along the Toledo and Ohio Central Railway between Toledo and Columbus—Continued.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Galatea, Baltimore and Ohio, and Toledo and Ohio Central crossing	41 10 40.8	83 38 42.8
Vanburen station, crossing 120 feet south of	41 08 17.5	83 38 42.8
Mortimer, crossing 465 feet south of railways	41 06 33.4	83 38 42.9
Mortimer station	41 06 38.0	83 38 42.9
Corner Ts. 1 and 2 N., Rs. 10 and 11 E	41 04 49.9	83 38 58.3
North Findlay, crossing of Lake Erie and Western Railway	41 02 50.7	83 38 42.2
Findlay, north azimuth stone at 790 feet north of "Big Four" crossing, 320 feet north of street, and 5 feet east of east rail of Toledo and Ohio Central Railway. A limestone post 36 by 7 by 5 inches, set 34 inches in the ground. A copper bolt is cemented in top	41 02 23.4	83 38 38.9
Findlay, south azimuth stone, 268 feet south of "Big Four" crossing, 4 feet north of sidewalk on Main street, and 17 feet west of west rail of Toledo and Ohio Central Railway. A limestone post 40 by 7 by 5 inches set 35 inches in ground, in center of top of which is cemented a bronze meridian tablet. Azimuth 178° 02′ 30″ to north stone	41 02 15.0	83 38 38.5
Findlay station	41 02 11.0	83 38 37.9
Findlay, crossing of Toledo and Ohio Central Railway and Findlay, Fort Wayne and Western Railway	41 01 20.4	83 38 32.2
Milepost 46, crossing 250 feet south of	41 00 28.2	83 38 28.1
Base line crossing	40 59 36.0	83 38 27.9
Milepost 49, crossing 130 feet south of	40 57 53.4	83 38 33.5
Milepost 51, crossing 200 feet south of	40 56 08.2	83 38 32.4
Corner Ts. 1 and 2 S., Rs. 10 and 11 E	40 54 23.3	83 39 03.7
Northern Ohio Railway crossing	40 53 56.8	83 38 48.7
Arlington station, crossing 180 feet north of	40 53 34.9	83 38 48.9
Milepost 56, crossing 470 feet south of	40 51 46.2	83 38 49.6
Williamstown station, crossing 70 feet south of	40 50 01.6	83 38 49.8
Corner Ts. 2 and 3 S., Rs. 10 and 11 E	40 49 09.7	83 39 04.6
Dunkirk station, crossing 900 feet north of	40 47 24.5	83 38 49.8
Pittsburg, Fort Wayne and Chicago Railway crossing	40 47 17.9	83 38 49.9
Milepost 64, crossing 910 feet south of	40 44 46.5	83 38 34.9
Blanchard station, 150 feet north of; telephone line road crossing	40 43 54.2	83 38 35.6
Milepost 67, crossing 500 feet south of	40 42 14.0	83 38 36.1
Milepost 69, crossing under railway 450 feet south of	40 40 30.3	83 38 35.1

Positions along the Toledo and Ohio Central Railway between Toledo and Columbus—Continued.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Pike crossing	40 39 19.2	83 37 59.9
Kenton, northwest azimuth stone 9 feet south of south rail on Toledo and Ohio Central Railway and 12 feet northwest of switch block. A sandstone post 30 by 6 by 6 inches, set 28 inches in ground, in center of top of which is cemented a bronze meridian tablet. Azimuth 273° 48′ 22″ to southeast stone	40 38 40.8	83 36 58.1
Kenton, southeast azimuth stone on middle pier of "Big Four" Railway bridge over Scioto River and Toledo and Ohio Central Railway: 15 feet south of Toledo and Ohio Central Railway and 3¼ feet west of west rail of "Big Four" Railway. A copper bolt in top of stonework	40 38 40.0	83 36 42.2
Kenton station, street crossing 140 feet east of	40 38 36.9	83 36 29.2
Erie Railway crossing	40 38 00.6	83 35 47.2
Siding, crossing 70 feet north of north end of	40 34 35.9	83 34 29.9
"Big Four" Railway crossing	40 31 09.6	83 33 47.6
Ridgeway station, crossing 175 feet south of	40 30 57.9	83 33 46.1
Mileposts 83 and 84, crossing halfway between, 1,450 feet north of creek	40 29 21.1	83 33 33.6
Milepost 86, crossing 480 feet north of	40 27 11.0	83 33 16.9
West Mansfield, main road running north from	40 24 34.8	83 32 46.7
Milepost 91, crossing 830 feet south of	40 22 59.3	83 31 24.0
Lunda station, crossing 400 feet south of	41 21 59.2	83 30 31.7
Raymonds station, crossing 180 feet northwest of	40 19 56.2	83 28 11.5
Peoria, Erie Railway crossing at	40 18 39.2	83 27 04.0
Milepost 98, crossing 1,340 feet south of	40 18 05.4	83 26 34.9
Siding, crossing 120 feet north of north end of	40 16 28.9	83 25 11.7
Marysville station, crossing 100 feet east of	40 14 25.7	83 22 13.5
Marysville, north azimuth stone at 940 feet north of "Big Four" crossing, 450 feet north of north end of Y, 200 feet north of east and west road, and 16 feet east of east rail of Toledo and Ohio Central Railway. A sandstone post 30 by 6 by 6 inches, set 26 inches in ground; in center of top is cemented a copper bolt	40 14 12.8	83 21 15.7
Marysville, south azimuth stone at 613 feet south of crossing of "Big Four" Railway, 6 feet east of east rail of Toledo and Ohio Central Railway. A sandstone post 30 by 6 by 6 inches, set 28 inches in ground, in center of top of which is cemented a bronze meridian tablet. Azimuth 139° 43′ 20″ to north stone	40 14 01.1	83 21 02.8

Positions along the Toledo and Ohio Central Railway between Toledo and Columbus—Continued.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Milepost 106, 330 feet south of pike and telephone line crossing	40 13 36.3	83 20 36.1
Milepost 108, crossing 1,350 feet south of	40 12 08.2	83 19 00.5
Blind siding, crossing 20 feet northwest of head block	40 10 06.4	83 16 48.5
Milepost 113, pike crossing 530 feet southeast of	40 08 54.0	83 15 30.0
Arnold station, 580 feet southeast of pike and telephone line crossing	40 08 27.4	83 15 01.2
Flag station, telephone line 200 feet southeast of	40 06 15.6	83 12 38.5
Amlin station, crossing 100 feet northwest of	40 04 36.4	83 10 51.1
Milepost 122, crossing 300 feet southeast of	40 02 54.5	83 09 01.0
Telephone-line crossing	40 01 56.6	83 07 58.4
Toledo and Ohio Central Railway and Pennsylvania Railway crossing	40 00 04.5	83 05 57.4
Milepost 127, crossing at	39 59 36.1	83 05 26.7

Meridian Marks.

BOWLING GREEN, WOOD COUNTY.

Location of station: In southwest corner of court-house grounds.

Station mark: A limestone post 36 by 7 by 5 inches, set 34 inches in the ground, in the center of top of which is countersunk and cemented a bronze tablet.

Reference mark: West line of grounds 21 feet; south line of grounds 12 feet.

Distant mark: North of station 352 feet, a limestone post 36 by 7 by 5 inches, set 36 inches in the ground, having a copper bolt cemented in its top.

Resident referee: County clerk.

DELAWARE, DELAWARE COUNTY.

Location of station: In western part of college grounds.

Station mark: A limestone post 36 by 6 by 6 inches, set 33 inches in the ground, in the center of top of which is countersunk and cemented a bronze tablet.

Reference mark: Fountain bears S. 68° W., distance 69 feet; western line of college grounds 50 feet east.

Distant mark: North of station 480 feet, a limestone post 24 by 6 by 6 inches, set 24 inches in the ground and having a copper bolt cemented in its top.

Resident referee: Custodian of college buildings.

FINDLAY, HANCOCK COUNTY.

Location of station: In southeast part of college grounds.

Station mark: A sandstone post 36 by 6 by 6 inches, set 32 inches in the ground, in the center of top of which is countersunk and cemented a bronze tablet.

Reference mark: Twenty-four feet from south fence, 15 feet from east fence, and 41 feet from water plug at corner.

Distant mark: North of station 525 feet, a sandstone post 36 by 6 by 6 inches, set 36 inches in the ground, having a copper bolt cemented in its top.

Resident referee: President of the school of the Church of God.

KENTON, HARDIN COUNTY.

Location of station: In southeast part of public-school yard.

Station mark: A sandstone post 36 by 7 by 7 inches, set 32 inches in the ground, in the center of top of which is countersunk and cemented a bronze tablet.

Reference marks: Thirty feet north of south fence and 18 feet from east fence and 36 feet from southeast corner of school yard.

Distant mark: North of station 315 feet, a sandstone post 30 by 6 by 6 inches, set 30 inches in the ground, having a copper bolt cemented in its top.

Resident referee: President of school board.

MARYSVILLE, UNION COUNTY.

Location of station: On church lot, 9 feet northeast of the northeast corner of Methodist Church.

Station mark: A sandstone post 36 by 6 by 6 inches, set 34 inches in ground, in center of top of which is countersunk and cemented a bronze tablet.

Reference marks: Twenty-seven feet from corner of street.

Distant mark: In the court-house grounds, north of station 375 feet, a sandstone post 30 by 6 by 6 inches, set 28 inches in the ground, having a copper bolt cemented in its top.

Resident referee: County clerk.

UPPER SANDUSKY, WYANDOT COUNTY.

Location of station: In southeastern part of public-school grounds, 10 feet north of sidewalk.

Station mark: A limestone post 36 by 7 by 7 inches, set 34 inches in the ground, in the center of top of which is countersunk and cemented a bronze tablet.

Reference marks: A white oak tree, 30 inches in diameter, bears N. 30 E., distant 48 feet.

Distant mark: North of station 348 feet, a limestone post 30 by 5 by 5 inches, set 30 inches in the ground, having a copper bolt cemented in its top.

Resident referees: School board.

WASHINGTON COURT-HOUSE, FAYETTE COUNTY.

Location of station: Two feet from curb line on north side of Temple street, in schoolhouse yard.

Station mark: A limestone post 36 by 8 by 8 inches, set 33 inches in the ground, in the center of top of which is countersunk and cemented a bronze tablet.

Reference marks: A locust tree 20 inches in diameter, bears S. 80° W., distant 40 feet; bay window in new schoolhouse, bears N. 40° E., distant 171 feet.

Distant mark: Three hundred feet north of station, a limestone post 30 by 6 by 6 inches, set 30 inches in the ground, having a copper bolt cemented in its top.

Resident referee: County clerk.

KENTUCKY AND INDIANA.

Primary Traverse.

Thirty-eight geographic positions in Kentucky and Indiana were determined from primary traverse by Mr. George T. Hawkins, topographer, in 1900.

This traverse starts from the Coast and Geodetic Survey astronomic pier at Henderson, Ky., and follows line of the Louisville, Henderson and St. Louis Railroad to Hawesville, Ky., crossing the Ohio River by triangulation, thence along the Cannelton branch of Louisville, Evansville and St. Louis Railroad to Lincoln City, Ind., connecting there with point on traverse run in 1899.

A spur line follows the wagon road from Hawesville, Ky., to southern edge of Rockford quadrangle.

Geographic positions along the Louisville, Henderson and St. Louis Railroad.

Station.	Latitude.	Longitude.
KENTUCKY.	° ′ ″	° ′ ″
Henderson, astronomic pier	37 50 24.8	87 35 26.1
Baskett, road crossing at	37 52 22.8	87 27 42.7
Spottsville	37 52 16.2	87 24 47.3
Worthington, road crossing at	37 50 18.2	87 17 42.7
Stanley, road crossing west of	37 49 31.8	87 14 42.2
Griffith, road crossing at	37 49 00.9	87 12 44.5
Road crossing near sawmill	37 48 39.6	87 10 04.9
Road crossing at store	37 48 25.2	87 09 15.2
Road crossing	37 47 18.5	87 08 27.8
Owensboro station	37 46 01.5	87 06 40.5
Crossing of Illinois Central and Louisville and Nashville railroads	37 46 11.5	87 05 34.8
Owensboro, road crossing east of	37 46 29.1	87 04 49.3
Thruston or Pates, road crossing at	37 47 56.3	87 03 07.4
Thruston or Pates, road crossing northeast of	37 49 26.1	87 01 52.9
Powers, road crossing at	37 51 57.0	86 59 39.3
Road crossing under railroad	37 53 35.6	86 58 58.8
Waitman, road crossing at	37 54 33.1	86 56 59.8
Lewisport, road crossing at	37 56 02.6	86 53 54.2
Lewisport, road crossing 2 miles east of	37 56 50.8	86 50 51.2
Falcon, road crossing at	37 57 07.5	86 49 33.8
Petri, road crossing at	37 55 44.4	86 48 14.5
Hawesville, crossing of Cross Main street	37 54 13.5	86 44 50.3

Geographic positions along the Louisville, Evansville and St. Louis Railroad.

Station.	Latitude.	Longitude.
INDIANA.	° ′ ″	° ′ ″
Cannelton, ferry landing at	37 54 36.6	86 44 40.6
Tell City depot	37 56 38.6	86 46 09.8
Windy Creek road crossing	37 59 06.6	86 47 11.6
Troy station	37 59 47.3	86 48 16.1
Road crossing at east end of big cut	38 02 11.3	86 49 11.2
Evanston, center of section 4, southeast of	38 02 21.5	86 50 18.5
Evanston station	38 02 24.9	86 50 25.0
T. 5 S., Rs. 4 and 5 W., secs. 19 and 24, ¼ corner between	38 04 06.1	86 54 14.0
Kennedy, road crossing at	38 04 46.6	86 55 22.3
T. 5 S., R. 5 W., secs. 9 and 10, ¼ corner between	38 05 55.1	86 57 34.9

Geographic positions along wagon road from Hawesville, Ky., to southern edge of Rockport quadrangle (spur Traverse Line).

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Hawesville, 2½ miles south of, forks of road	37 52 28.0	86 46 28.4
Chambers, forks of road east of	37 50 19.9	86 46 52.2
Corner of road 500 feet north of Pellville and Knottsville road	37 50 07.9	86 47 26.1
Floral, forks of road, 3 miles northeast of	37 49 26.6	86 47 22.1
Floral, forks of road, 1¼ miles northeast of	37 48 37.5	86 47 51.7
Floral, cross roads at	37 47 16.4	86 48 35.6
Floral, south azimuth mark	37 46 08.9	86 48 39.1

Meridian Marks.

OWENSBORO, DAVIES COUNTY, KY.

Location of station: In southeastern part of court-house grounds.

Station mark: A limestone post 36 by 7 by 7 inches, set 33 inches in the ground, in the center of top of which is countersunk and cemented an aluminum tablet.

Reference marks: Southeastern corner of court-house bears N. 30° W., distance 130 feet. Southeastern corner of grounds bears S. 50° E., distance 70 feet.

Distant mark: North of station 300 feet. A limestone post 36 by 7 by 7 inches, set 36 inches in the ground, having an aluminum tablet countersunk and cemented in its top.

Resident referee: County judge.

HAWESVILLE, HANCOCK COUNTY, KY.; CANNELTON, PERRY COUNTY, IND.

Location of station: In northeastern part of Hawesville, 30 feet north of railway, and on west bank of creek and south bank of Ohio River.

Station mark: A sandstone post 36 by 8 by 7 inches, set 36 inches in the ground, in the center of top of which is countersunk and cemented a bronze tablet.

Reference marks: Northeastern corner of Mr. Carter's yard fence bears S. 45° W., distance 70 feet. Locust tree 24 inches in diameter bears S. 15° W., distance 90 feet.

Distant mark: North of station about 2,700 feet, in Cannelton, Ind., in south part of town, on north bank of Ohio River, and 110 feet from and in front of Sunlight Hotel, a sandstone post 36 by 8 by 6 inches,set 36 inches in the ground, having a copper bolt cemented in its top.

Resident referee: County surveyor.

IOWA.

Primary Traverse.

Thirty-five geographic positions in northeastern Iowa determined from primary railroad traverse by Mr. George T. Hawkins, topographer, in 1899 and 1900.

The traverse begins at the junction of railways at Independence, previously located by primary traverse, and follows the Burlington, Cedar Rapids and Northern Railway to Postville, thence eastward along the Chicago, Milwaukee and St. Paul Railway to McGregor triangulation station of the Mississippi River Commission.

Geographic positions along the Burlington, Cedar Rapids and Northern Railway.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Independence, junction of railways at	42 28 42.7	91 54 28.9
T. 89 N., R. 9 W., corner secs. 21, 22, 27, and 28	42 29 54.7	91 54 18.9
T. 90 N., R. 9 W., corner secs. 27, 28, 33, and 34	42 34 15.1	91 54 20.8
T. 90 N., R. 9 W., corner secs. 9, 10, 15, and 16	42 36 52.6	91 54 18.7
Hazleton station	42 37 06.8	91 54 21.3
Crossing Chicago Great Western Railway	42 40 18.8	91 54 42.5
Oelwein station	42 40 44.9	91 54 42.3
T. 91 N., R. 9 W., center section 20	42 40 45.4	91 54 48.8
T. 91 N., R. 9 W., corner secs. 9, 10, 15, and 16	42 42 04.6	91 54 15.3
T. 92 N., R. 9 W., corner secs. 22, 23, 26, and 27	42 45 35.9	91 53 01.0
Maynard station	42 46 28.8	91 52 59.4
T. 93 N., R. 9 W., corner secs. 14, 15, 22, and 23	42 51 44.0	91 53 06.7
Randalia station	42 51 49.4	91 53 06.7
Crossing Chicago, Milwaukee and St. Paul Railway	42 53 47.3	91 52 43.2
T. 94 N., R. 9 W., corner secs. 25, 26, 35, and 36	42 55 16.6	91 51 54.6
West Union station	42 57 18.3	91 48 30.4
T. 94 N., R. 8 W., secs. 21 and 22, ¼ corner between	42 56 34.8	91 47 07.0
Brainard station	42 55 52.1	91 42 26.4
T. 94 N., R. 7 W., secs. 29 and 30, ¼ corner between	42 55 41.3	91 42 20.1
Elgin station	42 57 23.5	91 38 31.3
T. 94 N., R. 7 W., secs. 14 and 15, ¼ corner between	42 57 24.7	91 38 47.9
T. 94 N., R. 7 W., secs. 2, 3, 10, and 11, corner of	42 58 42.8	91 38 45.9
Clermont station	43 00 14.2	91 39 11.1
Postville, junction 3 miles west of	43 04 40.9	91 37.48.0

Geographic positions along the Chicago, Milwaukee and St. Paul Railroad.

Station.	Latitude.	Longitude.
Postville station	43 05 14.8	91 34 17.0
T. 96 N., R. 6 W., secs. 33 and 32, ¼ corner between	43 05 20.75	91 31 08.3
Luana station	43 03 32.66	91 27 09.3
Monona station	43 03 15.8	91 23 32.8
T. 96 N., R. 6 W., secs. 11, 12, 13, and 14, corner of	43 03 06.7	91 23 24.8
Valdora station	43 01 26.7	91 21 03.7
Beulah station	43 01 34.6	91 18 36.8
Giard station	43 02 15.0	91 15 42.4
West McGregor station	43 02 28.9	91 11 57.5
North McGregor, crossing of railroads at	43 02 38.6	91 10 42.3
McGregor, Mississippi River Commission triangulation station	43 03 31.93	91 10 49.35

MISSOURI.

Primary Traverse.

Fifty-seven geographic positions determined by primary railroad traverse by Mr. George T. Hawkins, topographer, in 1900.

Starting from U. S. Mississippi River Commission triangulation station Quincy, the traverse was run along the line of Omaha, Kansas City and Quincy Railroad to Kirksville; thence to Glenwood, via Wabash Railroad; thence eastward to Wayland, via Keokuk and Western Railroad, and there connected with U. S. Mississippi River Commission triangulation station Fox River.

Geographic positions along the Omaha, Kansas City and Quincy Railroad.

Station.	Latitude.	Longitude.
Quincy, Mississippi River Commission triangulation station	39 56 31.00	91 24 51.18
West Quincy station	39 56 07.0	91 26 09.1
Taylor station	39 56 17.5	91 31 18.0
Maywood station	39 57 11.3	91 35 56.1
T. 60 N., Rs. 6 and 7 W., secs. 31 and 36, ¼ corner between	39 57 15.6	91 37 02.3
Durham station	39 58 30.1	91 39 57.4
T. 60 N., R. 7 W., secs. 7, 8, 17, and 18, corner of	40 00 17.3	91 42 39.3
Ewing station	40 00 18.9	91 42 50.8
T. 61 N., R. 8 W., secs. 26 and 27, ¼, corner between	40 03 24.5	91 46 02.5

Geographic positions along the Omaha, Kansas City and Quincy Railroad—Continued.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Lewistown station	40 05 08.6	91 48 57.2
T. 61 N., R. 8 W., corner on range line between secs. 7 and 18	40 05 37.4	91 50 16.2
T. 61 N., R. 9 W., secs. 3, 4, 9, and 10, corner of	40 06 30.5	91 53 40.2
Labelle station	40 07 02.7	91 54 59.9
Knox station	40 08 35.1	92 00 38.5
T. 62 N., R. 10 W., secs. 19, 20, 29, and 30, corner of	40 09 11.3	92 02 35.6
T. 62 N., R. 11 W., secs. 20 and 21, ¼, corner between	40 09 39.7	92 08 00.9
T. 62 N., Rs. 11 and 12 W., secs. 19 and 24, ¼, corner between	40 09 41.6	92 10 30.8
Edina station	40 09 45.2	92 10 40.5
T. 62 N., R. 13 W., secs. 24 and 25, ¼, corner between	40 09 14.8	92 17 55.4
Hurdland station	40 09 06.5	92 18 09.7
Crossing Atchison, Topeka and Santa Fe Railway and Omaha, Kansas City and Quincy Railway	40 08 46.9	92 20 05.6
Brashear station	40 08 45.2	92 22 42.3
T. 62 N., R. 14 W., secs. 24 and 25, ¼, corner between	40 09 12.3	92 24 43.8
T. 62 N., Rs. 14 and 15 W., secs. 13 and 18, ¼, corner between	40 10 32.1	92 30 56.1
Kirksville, crossing Wabash railroad	40 12 05.0	92 35 10.5

Geographic positions along Wabash Railroad between Kirksville and Glenwood.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T. 63 N., R. 15 W., secs. 20 and 21, ¼, corner between	40 14 59.7	92 35 31.5
T. 65 N., R. 15 W., secs. 33 and 34, corner on township line between	40 18 03.1	92 34 22.6
Sublett station	40 18 09.8	92 34 13.0
Greentop station	40 20 47.6	92 34 03.3
Queen City station	40 24 28.7	92 34 09.6
T. 65 N., R. 15 W., corner secs. 21, 22, 27, and 28	40 25 27.8	92 34 41.4
Julesburg station	40 27 54.5	92 36 21.5

Geographic positions along or near Keokuk and Western railroad, between Glenwood and Wayland.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T. 66 N., R. 15 W., secs. 14, 15, 22, and 23, corner of	40 31 07.4	92 33 29.9
T. 66 N., R. 14 W., secs. 13 and 24, corner on range line between	40 31 09.3	92 31 14.3
Crossing of railroad and range line between Rs. 13 and 14, T. 66 N	40 30 13.9	92 24 57.6
T. 66 N., R. 13 W., secs. 28, 29, 32, and 33, corner of	40 29 29.8	92 22 16.6
Downing station	40 29 13.6	92 22 07.7
T. 65 N., R. 12 W., secs. 5 and 6, corner on township line between	40 28 39.3	92 16 29.3
Crawford station	40 28 28.4	92 16 29.0
Memphis station	40 27 13.8	92 09 56.9
T. 65 N., R. 11 W., secs. 8 and 9, ¼ corner between	40 27 22.4	92 08 04.2
T. 65 N., R. 11 W., secs. 10 and 11, ¼ corner between	40 27 20.1	92 05 47.3
Arbela station	40 24 49.6	92 00 58.8
Granger station	40 28 00.0	91 58 31.9
T. 65 N., R. 10 W., sec. 2, center of	40 28 05.7	91 58 31.4
T. 65 N., Rs. 9 and 10 W., crossing of railroad and range line between	40 27 41.4	91 56 43.6
Luray station	40 27 03.0	91 52 29.1
T. 65 N., R. 9 W., secs. 11 and 14, ¼ corner between	40 26 41.3	91 51 46.7
Ashton station	40 26 46.6	91 48 26.4
T. 65 N., R. 8 W., secs. 8, 9, 16, and 17, corner of	40 26 41.7	91 48 00.4
Crossing of Atchison, Topeka and Santa Fe Railroad	40 26 17.9	91 46 32.4
Kahoka station	40 25 22.1	91 43 02.4
Clark City	40 25 11.0	91 40 53.5
T. 65 N., R. 7 W., sec. 21, center of	40 25 09.5	91 40 23.9
T. 65 N., R. 6 W., secs. 29, 30, 31, and 32, corner of	40 23 41.8	91 35 16.1
Wayland station	40 23 42.2	91 35 07.4
Fox River, Mississippi River Commission triangulation station	40 21 34.82	91 35 20.87

MISSOURI-KANSAS.

Primary Traverse.

Forty geographic positions along or near the Kansas City, Fort Scott and Memphis Railway between the astronomic pier at Fort Scott, Kans., and the astronomic pier at Springfield, Mo., located from primary railroad traverse by Mr. George T. Hawkins, topographer, in 1900.

Geographic positions along the Kansas City, Fort Scott and Memphis Railway.

Station.	Latitude.	Longitude.
KANSAS.	° ′ ″	° ′ ″
Fort Scott astronomic pier	37 50 25.76	94 42 26.75
Washburn station	37 47 10.2	94 41 51.2
Clarksburg station	37 45 36.2	94 39 23.1
T. 26 S., R. 25 E., secs. 26, 27, 34, and 35, corner of	37 45 16.7	94 38 58.0
T. 26 S., R. 25 E., sec. 36, southeast corner of	37 44 49.4	94 38 24.4
Garland station	37 43 56.2	94 37 19.2
T. 27 S., R. 25 E., secs. 23, 24, 25, and 26, corner of	37 40 27.5	94 37 50.0
Arcadia, section corner ¼ mile west of	37 38 42.1	94 37 50.0
Arcadia station	37 38 38.7	94 37 40.0
Crossing of railway and Kansas-Missouri State line	37 37 47.8	94 37 03.6
MISSOURI.		
Last Chance station	37 36 18.5	94 35 29.2
Ts. 32 and 33 N., R. 33 W., secs. 2, 3, 34, and 35, corner of	37 38 58.8	94 31 59.0
Liberal, crossing of railroads	37 33 37.9	94 31 27.5
Liberal station	37 33 28.9	94 31 13.9
T. 32 N., R. 32 W., secs. 13, 14, 23, and 24, corner of	37 31 08.9	94 24 24.0
Iantha station	37 31 02.1	94 23 57.0
T. 32 N., Rs. 31 and 32 W., crossing of railway and range line between	37 30 59.1	94 23 18.4
Lamar station	37 29 13.8	94 16 44.9
T. 32 N., R. 30 W., sec. 32, ¼ corner, south side of	37 28 16.6	94 15 13.1
Kenoma station	37 26 17.9	94 11 58.3
T. 31 N., Rs. 29 and 30 W., secs. 18, 19, 24, and 13, corner of	37 25 31.2	94 10 18.0
Golden City station	37 24 01.3	94 05 28.7
T. 31 N., R. 29 W., sec. 26, center of	37 24 04.1	94 05 24.1
T. 31 N., R. 28 W., secs. 17, 18, 19, and 20, corner of	37 23 32.7	94 02 40.5
Lockwood station	37 23 16.0	93 57 17.4
T. 31 N., Rs. 27 and 28 W., crossing of railway and range line between	37 23 09.5	93 56 05.6
Fletcher station	37 22 46.4	93 53 44.8
T. 30 N., R. 26 W., sec. 6, ¼ corner north of	37 22 29.9	93 50 25.1
South Greenfield station	37 22 34.3	93 50 23.7
Pilgrim station	37 21 29.6	93 46 34.2
T. 30 N., R. 25 W., secs. 8 and 17, ¼ corner between	37 20 36.3	93 42 26.5
Everton station	37 20 28.3	93 42 19.8
Emmet station	37 19 32.0	93 39 35.8
T. 30 N., R. 24 W., secs. 20 and 21, ¼ corner between	37 19 04.5	93 35 19.3
Ash Grove station	37 19 01.9	93 35 16.2

Geographic positions along the Kansas City, Fort Scott and Memphis Railway—Continued.

Station.	Latitude.	Longitude.
MISSOURI—continued.	° ′ ″	° ′ ″
T. 30 N., R. 24 W., secs. 34 and 35, south corner of	37 16 52.9	93 33 12.1
T. 29 N., R. 24 W., secs. 1 and 1, 2 and 2, corner of	37 15 33.5	93 30 48.5
Bois D'Arc station	37 15 30.3	93 30 28.1
T. 29 N., R. 23 W., secs 9, 10, 15, and 16, corner of	37 13 43.2	93 26 28.1
Elwood station	37 13 35.3	93 25 55.9
Nichols Junction	37 13 10.2	93 21 52.9

The following positions were obtained by Mr. George T. Hawkins, topographer, in 1900, from primary traverse, which starts from Springfield, Mo., astronomic pier and follows the St. Louis and San Francisco Railroad to Oswego, Kans., where it was connected with the courthouse spire, located by astronomic methods in 1884.

Geographic positions along the St. Louis and San Francisco Railroad.

Station.	Latitude.	Longitude.
MISSOURI.	° ′ ″	° ′ ″
Springfield astronomic pier	37 13 15.96	93 17 17.58
Dorchester station	37 12 36.4	93 23 13.3
T. 28 N., R. 23 W., sec. 2, ¼ corner north of	37 10 12.0	93 24 56.7
Brookline station	37 09 50.2	93 25 12.7
Republic station	37 07 11.1	93 28 53.2
T. 28 N., R. 23 W., secs. 19 and 20, ¼ corner between	37 07 09.9	93 28 52.6
T. 27 N., R. 24 W., secs. 4, 5, 8, 9, corner of	37 04 10.1	93 33 18.3
Billings station	37 04 03.4	93 33 19.9
Logan, section corner just east of	37 01 07.0	93 36 37.7
Logan station	37 00 51.8	93 37 00.6
Marionville station	36 59 59.9	93 37 53.0
Aurora station	36 58 37.5	93 43 16.2
T. 26 N., R. 26 W., secs. 11 and 12, ¼ corner between	36 58 38.1	93 44 11.8
Verona station	36 57 54.0	93 47 52.4
T. 26 N., R. 26 W., secs. 17 and 20, ¼ corner between	36 57 24.6	93 47 59.5
T. 26 N., R. 27 W., secs. 25 and 30, ¼ corner between	36 56 07.7	93 49 39.1
Globe station	36 55 53.6	93 51 09.4
Monett station	36 55 14.6	93 55 19.8
Pierce City, secs. 21 and 28, ¼ corner between	36 56 46.5	94 00 00.2
Pierce City station	36 56 41.8	94 00 10.9
Snyder station	36 58 01.7	94 01 10.6
T. 26 N., R. 28 W., secs. 17 and 18, ¼ corner between	36 58 07.1	94 01 31.9

Geographic positions along the St. Louis and San Francisco Railroad—Continued.

Station.	Latitude.	Longitude.
MISSOURI—continued.	° ′ ″	° ′ ″
Wentworth station	36 59 43.6	94 04 23.5
Talmage station	37 00 58.1	94 05 36.2
Talmage, section corner at	37 01 15.7	94 05 46.3
T. 27 N., R. 29 W., secs. 20 and 21, ¼ corner between	37 02 35.6	94 06 48.4
Sarcoxie station	37 04 03.0	94 07 01.1
T. 28 N., R. 30 W., secs. 25 and 36, corner on range line between	37 06 34.4	94 08 51.4
Reeds station	37 07 06.1	94 10 04.5
T. 28 N., R. 30 W., secs. 17, 18, 19, 20, corner of	37 08 27.1	94 14 14.8
Knights station	37 08 35.2	94 14 59.6
T. 28 N., R. 31 W., secs. 11, 12, 13, 14, corner of	37 09 20.4	94 16 26.0
Carthage station	37 11 06.1	94 18 35.7
T. 28 N., R. 31 W., sec. 6, one-fourth corner west of (elevation 960 feet)	37 10 39.2	94 20 42.7
Crossing, north and south (elevation 998 feet)	37 10 44.1	94 21 53.8
Macy station	37 11 11.6	94 23 48.0
Mansur station	37 11 40.6	94 25 07.2
Boysur, road crossing	37 11 46.1	94 26 44.8
Joplin Junction, head block	37 11 43.6	94 27 44.3
T. 29 N., R. 33 W., secs. 25, 26, 35, and 36, corner of	37 12 03.0	94 29 24.6
T. 28 N., R. 33 W., secs. 4 and 5, corner on township line between	37 11 17.0	94 32 40.1
Crossing, Missouri Pacific Railway	37 11 08.3	94 32 49.5
Carl Junction	37 10 46.5	94 33 50.5
Smithfield station	37 10 10.6	94 36 09.1
Missouri-Kansas State Line and "Frisco" Railway, crossing of	37 10 01.6	94 37 02.9
KANSAS.		
T. 33 S., R. 25 E., secs. 17 and 18, ¼ corner between	37 10 17.4	94 42 13.3
Crestline station	37 10 17.4	94 42 17.1
T. 33 S., R. 24 E., secs. 13 and 14, ¼ corner between	37 10 17.6	94 44 24.6
T. 33 S., R. 24 E., secs. 16 and 17, ¼ corner between	37 10 18.1	94 47 41.3
Kansas City, Pittsburg and Gulf Rwy., crossing of	37 10 35.4	94 50 12.1
Columbus station	37 10 34.2	94 50 32.4
Sherwin, crossing of Missouri Pacific R. R	37 10 48.6	94 56 51.5
T. 33 S., Rs. 22 and 23 E., secs. 7, 18, 12, 13, corner of	37 10 47.9	94 57 29.0
Oswego, section corner 3 miles east of	37 09 56.3	95 02 56.5
Oswego, court-house spire	37 09 58.9	95 06 24.0

Meridian Marks.

EDINA, KNOX COUNTY, MO.

Location of station: In court-house square.

Station mark: A granite post 36 by 6 by 6 inches, set 34 inches in the ground, 15 feet north of east and west walk and 78 feet from fence on east side of grounds. In center of top of the post is countersunk and cemented a bronze tablet.

Distant mark: Four hundred feet north of station, a marble post 20 by 6 by 6 inches, set 20 inches in the ground, in center of top of which is cemented a copper bolt. Stone is 10 feet south of east and west fence on north side of square and 80 feet from fence on east side of grounds.

Resident referee: County clerk.

CARTHAGE, JASPER COUNTY, MO.

Location of station: In west part of Central Park.

Station mark: A limestone post 42 by 8 by 6 inches, set 40 inches in the ground, in the center of top of which is countersunk and cemented a bronze tablet.

Reference marks: Forty-eight feet from southwest corner of park and 1 foot from line of fence.

Distant mark: North of station 252 feet, a limestone post 30 by 8 by 6 inches, set 28 inches in ground and with a copper bolt cemented in its top.

Resident referee: County clerk.

KAHOKA, CLARK COUNTY, MO.

Location of station: In eastern part of court-house grounds.

Station mark: A marble post 36 by 6 by 6 inches, set 32 inches in the ground, in the center of top of which is countersunk and cemented a bronze tablet.

Reference marks: An ash tree 10 inches in diameter N. 73° W., distant 24 feet. An ash tree 14 inches in diameter N. 60° E., distant 15 feet.

Distant mark: North of station 300 feet, on inside line of sidewalk on north side of grounds, a marble post 30 by 6 by 6 inches, set 30 inches in the ground; has a copper bolt cemented in its top.

Resident referee: County clerk.

KIRKSVILLE, ADAIR COUNTY, MO.

Location of station: In northwest part of Normal School grounds.

Station mark: A limestone post 36 by 6 by 6 inches, set 34 inches in the ground, in the center of top of which is countersunk and cemented a bronze tablet.

Reference marks: A maple tree 10 inches in diameter bears N. 40° E., distant 63 feet. A maple tree 24 inches in diameter bears S. 80° W., distant 72 feet.

Distant mark: A limestone post 24 by 6 by 6 inches, set 24 inches in the ground, 360 feet north of station, 28 feet southwest of large maple tree, and 120 feet from northwest corner of grounds. Stone post has a copper bolt cemented in center of its top.

Residence referee: County clerk.

LAMAR, BARTON COUNTY, MO.

Location of station: In western part of court-house grounds.

Station mark: A limestone post 36 by 8 by 8 inches, set 34 inches in the ground, in the center of top of which is countersunk and cemented a bronze tablet.

Reference marks: Southwest corner of court-house N. 35° E., distant 132 feet. Southwest corner of grounds bears S. 50° W., distant 63 feet.

Distant mark: North of station 322 feet, a limestone post 24 by 9 by 9 inches, set 24 inches in the ground, with copper bolt in its top.

Resident referee: County clerk.

LANCASTER, SCHUYLER COUNTY, MO.

Location of station: In east part of public-school yard.

Station mark: A limestone post 40 by 8 by 6 inches, set 30 inches in the ground, in the center of top of which is countersunk and cemented a bronze tablet.

Reference marks: Southeast corner of schoolhouse N. 10° 30′ W., distant 123 feet; 3 feet from south line and 45 feet from east line of grounds.

Distant mark: North of station 276 feet, on line of sidewalk on north side of street, 36 feet west of street corner, a limestone post 30 by 8 by 8 inches, set 30 inches in ground, having a copper bolt cemented in its top.

Resident referee: County clerk.

MEMPHIS, SCOTLAND COUNTY, MO.

Location of station: In eastern part of high-school grounds.

Station mark: A limestone post 40 by 8 by 6 inches, set 36 inches in the ground, in the center of top of which is countersunk and cemented a bronze tablet.

Reference marks: Southeast corner of schoolhouse N. 16° W., distant 123 feet. Maple tree 8 inches in diameter bears N. 74° E., distant 30 feet.

Distant mark: North of station 290 feet and 4 feet south of north fence. A limestone post 30 by 8 by 8 inches, set 30 inches in the ground, with copper bolt cemented in the top.

Resident referee: County clerk.

COLUMBUS, CHEROKEE COUNTY, KANS.

Location of station: In eastern part of court-house grounds.

Station mark: A limestone post 36 by 6 by 6 inches, set 34 inches in the ground, in the center of top of which is countersunk and cemented a bronze tablet.

Reference marks: Southeastern corner of court-house N. 50° W., distant, 84 feet. It is 21 feet from south line and 30 feet from east line of grounds.

Distant mark: North of station 270 feet. A limestone post 24 by 6 by 6 inches, set 24 inches in the ground, in the center of top of which is set a copper bolt.

Resident referee: County clerk.

ARKANSAS.

Primary Traverse.

Twenty-two geographic positions, determined by Mr. Geo. T. Hawkins, topographer, from primary traverse in Arkansas, in 1900. The line starts from a position in front of station at Gurdon, established by primary traverse in 1898, and follows the St. Louis, Iron Mountain and Southern Railway to Camden; thence along the St. Louis and Texas Railway to Harlow.

Geographic positions in Arkansas.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Gurdon station	33 55 08.0	93 09 12.1
Whelan station	33 49 47.1	93 07 36.3
Sayre, road crossing at	33 45 04.3	93 05 32.3
T. 11 S., R. 19 W., secs. 29 and 30, ¼ corner between	33 45 02.7	93 05 15.2
Basham station	33 43 21.7	93 03 14.0
Chidester station	33 42 07.9	93 01 14.1
T. 12 S., R. 19 W., secs. 11, 12, 13, 14, corner of	33 41 55.1	93 01 10.4
Van Wagoner station	33 41 00.9	92 59 15.1
Wise station	33 39 30.9	92 56 02.5
Lester, crossing ¼ mile north of	33 38 56.0	92 55 06.8
Camden, at road crossing 1 mile northwest of, iron bench-mark post, elevation 143 feet	33 35 44.9	92 51 10.5
Camden, crossing of telephone line	33 34 55.8	92 50 00.6

Geographic positions in Arkansas—Continued.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Camden, crossing, street to Iron Mountain station at south end of bridge	33 34 51.0	92 49 41.4
Camden, road crossing at post-office 4 miles northeast of	33 39 02.9	92 46 24.7
Lilley station	33 40 09.3	92 44 25.2
Onalaska station	33 40 19.8	92 43 57.6
Eagle Mill station	33 40 53.2	92 42 30.5
Millville station	33 42 22.7	92 39 19.1
T. 11 S., R. 15 W., secs. 34 and 35, ¼ corner between	33 43 30.6	92 37 14.5
Bearden station	33 43 22.1	92 36 58.6
Best station	33 43 40.9	92 36 18.3
Harlow station	33 44 45.3	92 33 59.8

Meridian Marks.

CAMDEN, OUACHITA COUNTY, ARK.

Location of station: In western part of court-house grounds.

Station mark: A limestone post 42 by 8 by 8 inches, set 38 inches in the ground, in the center of top of which is countersunk and cemented a bronze tablet.

Reference marks: 27 feet from west gate, 39 feet from west door of court-house, and 6 feet south of walk.

Distant mark: 260 feet north of station, in northern part of Methodist churchyard, across street from court-house, 2 feet from north line of churchyard and 10 feet from north wall of church, a limestone post 30 by 8 by 8 inches, set 30 inches in the ground, having a copper bolt set in center of its top.

Resident referee: County clerk.

ROCKY MOUNTAIN SECTION OF TOPOGRAPHY.

SOUTH DAKOTA-WYOMING.

Triangulation Stations.

In 1900 Mr. A. F. Dunnington, topographer, executed control for the Edgemont quadrangle by reoccupying Fossil, Bradley, Sullivan, and Alkali, and establishing two new stations—Provo and Cottonwood. He also extended triangulation northward from Terry Peak, Bear Butte, and Crow Peak, occupying eight new stations, controling three 30-minute quadrangles.

PROVO, FALL RIVER COUNTY, S. DAK.

On highest point of knob on west end of bald ridge 2 miles southeast of Provo station, Burlington and Missouri River Railroad, and about 10 miles south of Edgemont.

Station mark: A bronze bench-mark tablet cemented in sandstone, 9 by 13 by 6 inches, set flush with surface of ground.

[Latitude 43° 10′ 18.03″. Longitude 103° 48′ 12.52″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Cottonwood	111 22 38.98	291 10 41.84	4.4043384
Sullivan	161 40 02.55	341 32 07.30	4.6932508
Bradley	208 34 01.20	28 41 37.58	4.4956729
Fossil	261 06 55.77	81 19 23.45	4.3973066

COTTONWOOD, CONVERSE COUNTY, WYO.

This station is on the highest point of the bald divide, about 2½ miles west of the Dakota-Wyoming State line. It is 6 miles northwest of the junction of Alum and Cottonwood creeks and about 2½ miles southwest of south end of hay road, which bears southwest, and leaves the Edgemont and Lance Creek wagon road about 8 miles west of Edgemont.

Station mark: A bronze bench-mark tablet set in sandstone, 10 by 10 by 6 inches, 3 inches below surface of ground; a mound of small stones was erected over tablet.

[Latitude 43° 15′ 16.38″. Longitude 104° 05′ 39.88″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Alkali Butte	143 49 32.35	323 33 37.12	4.7222453
Sullivan	191 57 58.51	12 02 02.85	4.5849751
Provo	291 10 41.84	111 22 38.98	4.4043384

OWL BUTTE, BUTTE COUNTY, S. DAK.

A lone, bare butte in open prairie about 35 miles northeast of Sturgis, on divide east of Willow Creek. Station is near the center of summit.

Station mark: A bronze triangulation tablet cemented in rock in place.

[Latitude 44° 48′ 20.27″. Longitude 103° 18′ 05.18″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bear Butte	28 36 51.15	208 28 22.65	4.6012777
Susie Peak	79 32 16.68	259 10 20.70	4.6212654
Castle Rock	141 36 30.14	321 26 47.25	4.4640921

CASTLE ROCK, BUTTE COUNTY, S. DAK.

A prominent peak in T. 12 N., R. 5 E., Black Hills meridian, 28 miles air line northeast of Belle Fourche, 12 miles southwest of junction of Sand Creek and South Fork of Moreau River. The summit is a narrow ridge about 150 yards in length, the station being on a knob at northern end, which is about 10 feet lower than south end. Road from Belle Fourche to Slim Buttes passes from southwest to northeast about 2 miles east of the peak.

Station mark: A bronze triangulation tablet cemented in a flat rock buried in the ground flush with surface.

[Latitude 45° 00′ 38.65″. Longitude 103° 26′ 50.82″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Susie Peak	36 58 45.39	216 46 29.57	4.5814773
Wymonkota	90 11 12.42	269 44 24.24	4.6971830
Owl Butte	321 26 47.25	141 36 30.14	4.4640921
Bear Butte	357 49 38.82	177 50 48.88	4.7740756

SUSIE PEAK, BUTTE COUNTY, S. DAK.

A small conical peak near the center of T. 9 N., R. 3 E., Black Hills meridian, situated on east end of a high ridge bearing southeast and northwest, being the divide between Crow and Owl creeks, about 6 miles northeast of the town of Belle Fourche and about 2 miles north of Belle Fourche River.

Station mark: A bronze triangulation tablet cemented in stone sunk flush with surface of ground.

[Latitude 44° 44′ 10.08″. Longitude 103° 44′ 13.75″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Terry	8 09 49.51	189 05 58.21	4.6616893
Crow Peak	30 34 32.16	210 25 19.14	4.5342997
Warren Peak	63 20 21.79	242 50 33.50	4.7991448
Wymonkota	138 34 02.37	318 19 33.87	4.6099751
Castle Rock	216 46 29.57	36 58 45.39	4.5814773
Owl Butte	259 10 20.70	79 32 16.68	4.6212654
Bear Butte	318 43 45.57	138 57 09.55	4.5898871

WYMONKOTA, CUSTER COUNTY, MONT.

A small conical peak situated in southeastern corner of State, on bare divide between Owl and Lone Tree creeks, about one-half mile southeast of head of the latter, about 2 miles west of Watson's sheep ranch, and about 1½ miles west of the "Hash Knife" road from Belle Fourche.

Station mark: A bronze triangulation tablet cemented in large rock set in ground.

[Latitude 45° 00′ 37.62″. Longitude 104° 04′ 44.71″.]

To station—	Azimuth.	Back azimuth.	Log distance.
	° ′ ″	° ′ ″	*Meters.*
Warren	26 15 49.71	206 00 23.64	4.8175736
Alzada	70 47 36.29	250 30 27.84	4.5290474
Castle Rock	269 44 24.24	90 11 12.42	4.6971830
Susie Peak	318 19 33.87	138 34 02.37	4.6099751
Crow Peak	350 43 02.11	170 48 14.23	4.7836118

ALZADA, CROOK COUNTY, WYO.

A bald peak, most southerly of group of bare hills, about 8 miles southwest from Alzada post-office, Mont., on the divide between the Little Missouri and Belle Fourche rivers, about 6 miles southwest from the big bend of the latter, and about 5 miles south of the Wyoming-Montana line.

Station mark: A bronze triangulation tablet cemented in stone sunk below surface of ground between two large rocks bearing southeast and northwest about 3½ feet apart, the southeast rock 30 by 18 inches, 5 inches above ground, and the northwest rock 24 by 8 inches, 12 inches above ground.

[Latitude 44° 54′ 34.73″. Longitude 104° 29′ 00.17″.]

To station—	Azimuth.	Back azimuth.	Log distance.
	° ′ ″	° ′ ″	*Meters.*
Wymonkota	250 30 27.84	70 47 36.29	4.5290474
Crow Peak	319 12 17.68	139 34 33.11	4.8078017
Warren Peak	356 17 47.66	176 19 26.09	4.6801626

WARREN PEAK, CROOK COUNTY, WYOMING.

The most easterly of the two high bare summits of the Bear Lodge Mountains, about 6 miles northwest of the town of Sundance, Wyoming, at the head of Bear and Miller creeks. Richardson's ranch lies about 6 miles north, on Beaver Creek. Road from ranch to Sundance passes about three-fourths of a mile northeast of station.

Station mark: A bronze triangulation tablet cemented in stone in place on highest point, 6 feet southeast of a mining claim stake in cairn of rocks.

[Latitude 44° 28' 46.79". Longitude 104° 26' 40.28".]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ' "	° ' "	*Meters.*
Alzada	176 19 26.09	356 17 47.66	4.6801636
Wymonkota	206 00 23.64	26 15 49.71	4.8175736
Susie Peak	243 50 33.50	63 20 21.79	4.7991448
Belle Fourche	244 47 34.89	65 12 58.96	4.7230707
Crow Peak	271 16 58.99	91 37 31.39	4.5896094

BELLE FOURCHE, BUTTE COUNTY, SOUTH DAKOTA.

A three-point station on summit of a sandy hill north of Belle Fourche River, a meridian mark distant 1,570 feet north of south meridian station, which is in the grounds of the county court-house in Belle Fourche.

Station mark: A sandstone post, 30 by 12 by 12 inches, set 25 inches in the ground, in the top of which is cemented a bronze meridian tablet.

[Latitude 44° 40' 50.31". Longitude 103° 50' 28.93".]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ' "	° ' "	*Meters.*
Crow Peak	21 21 15	201 16 25	4.3984959
Warren Peak	65 12 59	244 47 35	4.7230707
Susie Peak	233 12 58	53 17 22	4.0131451

DEER EARS, BUTTE COUNTY, SOUTH DAKOTA.

(Not occupied.)

The south summit of a double-topped hill known as "Deer Ears," near the line between T. 12 N., Rs. 7 and 8 E., Black Hills meridian.

[Latitude 44° 59' 57.09". Longitude 103° 10' 41.88".]

STATE CORNER—WYOMING, MONTANA, AND SOUTH DAKOTA.

The stone post marking the corner common to Wyoming, Montana, and South Dakota, being the northeast corner of Wyoming.

Station mark: A white sandstone, 18 by 22 inches, 20 inches above ground, bearing no marks; against this rests a triangular sandstone column, 50 inches long, which has fallen from its original position above the other, one side 16 inches wide marked "Dak. 45 N. L.," underneath "27 W. L.;" one side 12 inches wide marked "N. W. Mont.," and the other 12 inches wide marked "S. W. Wyo." Three pits, each 4 feet square, lie north, west, and south of mark.

[Latitude 44° 59′ 54.0″. Longitude 104° 03′ 02.4″.]

STATE CORNER, MONTANA AND SOUTH DAKOTA.

(Not occupied.)

The stone post marking the southeast corner of Montana.

Station mark: A stone, 20 by 8 inches, 33 inches above ground. Among a lot of large loose stones on ground, one is marked on one side "Wyo.," on another side "Mon. 45 N. L.," and another stone is marked "Dak. 27 W. L."

Reference marks: Three stones set in ground 6 feet distant east, northwest, and southwest from station are marked on top "D.," "M.," and "W.," respectively.

[Latitude 44° 59′ 55.7″. Longitude 104° 01′ 57.3″.]

Meridian Mark.

BELLE FOURCHE, BUTTE COUNTY, SOUTH DAKOTA.

Location of station: In grounds of county court-house.

Station mark: Red sandstone post, 60 by 10 by 10 inches, set 56 inches in the ground, in center of top of which is cemented a bronze bench-mark tablet.

Reference mark: Southeast corner of court-house, distant 47.75 feet. True azimuth to same is 167° 10′.

Distant mark: North of station 1,570 feet, on summit of sand hill north of Belle Fourche River, a sandstone post, about 30 by 12 by 12 inches, set 25 inches in the ground, in top of which is cemented a meridian tablet.

TEXAS.

Triangulation Stations.

In March, April, and May, 1900, triangulation control was extended from stations County Line, Dexter, Tex., and Marietta, Ind. T., westward over the Gainesville and Montague quadrangles, by Mr. R. H. Chapman, topographer.

In addition to the occupation of the three old stations, nine new stations were selected and occupied, and four points were located by intersections.

HENSON, COOKE COUNTY.

On a rocky, thinly timbered hill, about 6 miles northeast of Gainesville, about 150 yards northeast of Henson's house, about 6 miles southwest from Callisburg, and one-half mile east of Gainesville-Whitesboro road.

Theodolite elevated 18 feet.

Station mark: A bronze tablet cemented in rock in place level with surface.

Reference marks: Nail in base blaze on post oak, azimuth 129° 13′, distance 42 feet; nail in base blaze on post oak, azimuth 243° 54′, distance 18.9 feet; nail in base blaze on post oak, azimuth 12° 54′, distance 14.2 feet.

[Latitude 33° 38′ 45.87″. Longitude 97° 08′ 24.41″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hood	70 11 31.76	250 02 27.00	4.4311207
Hemphill	107 57 58.85	287 51 01.20	4.3094593
Huneycutt	173 35 18.33	353 34 54.10	4.0030463
County Line	227 02 59.91	47 06 06.66	4.0737988

HUNEYCUTT, COOKE COUNTY.

On a flat, timbered ridge, about 12 miles northeast of Gainesville, about one-eighth mile west of Gainesville-Horseshoe Bend road, and one-half mile northwest of the widow Huneycutt's house, from which a wood road passes station. Due east from station is a very sandy field.

Theodolite elevated 18 feet.

Station mark: A bronze tablet cemented in rock in place about inches under surface of ground.

Reference marks: Nail in blaze on black-oak tree, azimuth 302° 13′, distance 36.65 feet; nail in blaze on post-oak tree, azimuth 44° 32′, distance 24.10 feet; nail in blaze on post-oak tree, azimuth 142° 31′, distance 33.70 feet.

[Latitude 33° 44′ 10.69″. Longitude 97° 04′ 08.10″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hood	51 41 32.10	231 33 50.90	4.4901191
Hemphill	78 29 38.85	258 23 04.96	4.2706120
Marietta	175 10 59.88	355 10 22.26	4.3153385
Dexter	229 01 55.28	49 05 48.81	4.1555001
County Line	281 08 41.03	101 12 12.24	3.9994935
Henson	353 34 54.10	173 35 18.33	4.0030463

GAINESVILLE, THIRD WARD SCHOOL, COOKE COUNTY.

(Not occupied.)

Station mark: Middle of statue on cupola of Third Ward school uilding.

[Latitude 33° 38′ 04.48″. Longitude 97° 08′ 51.86″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hemphill	124 33 22.25	304 29 26.20	4.1243076
Henson	261 22 52.45	81 25 53.85	3.9311680

HEMPHILL, COOKE COUNTY.

On a high, rolling prairie, about 11 miles northwest from Gainesville, in pasture owned by J. C. Hemphill, just east of line of posts no wire) running north and south and on highest point in vicinity. t is one-half mile northeast from Hemphill homestead, one-fourth mile north of house occupied by J. R. Bice, and about 1 mile northast of Van Slack church.

Station mark: A bronze tablet in sandstone post 36 by 8 by 10 nches, set 32 inches in the ground.

[Latitude 33° 42′ 09.39″. Longitude 97° 15′ 57.65″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hood	21 05 53.53	201 03 45.56	4.2189604
Muenster	62 36 24.98	242 32 46.93	4.0573381
Meador	92 24 21.45	272 17 30.02	4.2812156
Marietta	214 06 33.63	34 12 30.88	4.4684405
Dexter	245 38 15.59	65 48 43.34	4.5036342
Huneycutt	258 23 04.96	78 29 38.85	4.2706120
Henson	287 51 01.20	107 57 58.85	4.3094543

HOOD, COOKE COUNTY.

On a high, rolling prairie ridge, about 12 miles southwest from Gainesville, 2 miles northeast from Hood post-office, and 5 miles southwest from Myra post-office. In pasture owned by W. P. Gregory, 57 yards northeast from J. F. Hood's house, one-half mile south of W. P. Gregory's house, and 6 feet west of fence on west side of road from Myra to Hood. It is 52 feet 4 inches north (6 feet west) of corner post on line of Gregory and Hood property, between Gainesville-Rosston and Gainesville-Forrestburg roads.

Station mark: A bronze tablet in sandstone post 30 by 8 by 8 inches, set 30 inches in the ground.

[Latitude 33° 33′ 47.98″. Longitude 97° 19′ 48.70″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Jackson	102 32 46.31	282 29 16.77	4.0004447
Meador	141 01 13.31	320 56 30.61	4.3199664
Muenster	157 42 37.58	337 41 07.82	4.0420488
Hemphill	201 03 45.56	21 05 53.58	4.2189604
Hunneycutt	231 33 50.90	51 42 32.10	4.4901191
Henson	250 02 27.00	70 11 31.76	4.4311207

MUENSTER, COOKE COUNTY.

The belfry on the Roman Catholic Church at Muenster was occupied at a point about 45 feet above ground.

Station mark: Gilt cross on spire of church.

[Latitude 33° 39′ 18.81″. Longitude 87° 22′ 30.87″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Jackson	34 52 06.74	214 50 06.74	3.9901891
Jim Ned	78 57 58.34	258 49 28.52	4.3833586
Meador	123 58 48.57	303 55 35.45	4.0339101
Hemphill	242 32 46.93	62 36 24.98	4.0573381
Hood	337 41 07.82	157 42 37.58	4.0420488

JACKSON, COOKE COUNTY.

On a high rolling prairie, about 7 miles southwest of Muenster and 7 miles northwest from Hood (post-office), one-half mile north of Gainesville-Forrestburg road, in pasture owned by J. S. Jackson, one-half mile northward from his house. Higher ground under cultivation lies one-fourth mile northward of station.

Station mark: A bronze tablet set in fossiliferous limestone post, 24 by 8 by 8 inches, set 24 inches in ground.

[Latitude 33° 34′ 58.40″. Longitude 97° 26′ 07.61″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Jim Ned	100 34 01.41	280 27 32.01	4.2660752
Muenster	214 50 06.74	34 52 06.74	3.9901891
Hood	282 29 16.77	102 32 46.31	4.0004447

MEADOR, MONTAGUE COUNTY.

On a prairie knoll, with few small trees, about 4 miles northeast of Saint Jo and 1 mile north of Missouri, Kansas and Texas Railway track, in "stack" yard owned by Meador Bros. (Saint Jo). The Saint Jo-Marysville road passes about 400 yards west of station.

Theodolite elevated 18 feet.

Station mark: A bronze tablet cemented in a stone post, about 36 by 8 by 10 inches, set 36 inches in ground.

[Latitude 33° 42′ 34.81″. Longitude 97° 28′ 19.05″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Jim Ned	54 05 15.87	232 59 58.68	4.2604098
Saint Jo	76 43 55.23	256 42 19.02	3.6615794
Mosley	94 54 05.67	274 50 04.80	4.0497723
Hemphill	272 17 30.02	92 24 21.45	4.2812156
Muenster	303 55 35.45	123 58 48.57	4.0339101
Hood	320 56 30.61	141 01 13.31	4.3199664

SAINT JO (SCHOOLHOUSE), MONTAGUE COUNTY.

(Not occupied.)

Station mark: Point of cupola on brick schoolhouse at Saint Jo.

[Latitude 33° 42′ 00.60″. Longitude 97° 31′ 12.44″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Jim Ned	46 51 37.99	226 47 56.93	4.1489547
Mosley	106 39 41.46	286 37 17.02	3.8452950
Meador	256 42 19.02	76 43 55.23	3.6615794

MOSLEY, MONTAGUE COUNTY.

On northern point of prairie ridge, about 5 miles west of Saint Jo, 3 miles south of Bonita and one-half mile south of Saint Jo-Nocona road, in pasture owned by Luke Mosley, who lives about one-half mile northeast from station.

Station mark: A bronze tablet set in a stone post, 30 by 10 by 8 inches, set 23 inches in the ground.

Reference mark: Nail in blaze on north side of tree 4 inches in diameter. Azimuth, 333° 32′; distance, 55 feet.

[Latitude 33° 43′ 05.70″. Longitude 97° 35′ 33.01″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Jim Ned	17 01 14.61	196 59 57.95	4.0856216
Bowie	55 00 48.97	234 52 13.30	4.4669171
Montague	63 16 22.11	243 12 08.91	4.1194725
Meador	274 50 04.80	94 54 05.67	4.0497723
Saint Jo	286 37 17.02	106 39 41.46	3.8452950

JIM NED, MONTAGUE COUNTY.

On highest point of a bare, flat hill known as "Jim Ned Lookout," about 8 miles southwest from Saint Jo, 8 miles southeast from Montague Court-House, and 1 mile south of Dye post-office, in pasture owned by B. R. Raymond, who lives one-half mile southwest from station. The Dye-Bowie road passes one-eighth mile west of station. Theodolite elevated 18 feet.

Station mark: A bronze tablet cemented in sandstone post, 30 by 10 by 8 inches, set 28 inches in ground.

[Latitude 33° 36′ 47.68″. Longitude 97° 37′ 51.31″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bowie	75 49 20.60	255 42 02.15	4.3239329
Montague	124 54 50.57	304 51 54.33	3.9998274
Mosley	196 59 57.95	17 01 14.61	4.0856216
Meador	233 59 58.68	54 05 15.87	4.2604098
Muenster	258 49 28.52	78 57 58.34	4.3833586
Jackson	280 27 32.01	100 34 01.41	4.2660752
Saint Jo	226 47 56.93	46 51 37.99	4.1489547

MONTAGUE COURT-HOUSE, MONTAGUE COUNTY.

(Not occupied.)

Station mark: Figure of Justice on tower of court-house at Montague.

[Latitude 33° 39′ 53.27″. Longitude 97° 43′ 09.46″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Mosley	243 12 08.91	63 16 22.11	4.1194725
Jim Ned	304 51 54.33	124 54 50.57	3.9998274

BOWIE, MONTAGUE COUNTY.

(Not occupied.)

Station mark: Middle of top of standpipe in town of Bowie.

[Latitude 33° 33′ 59.37″. Longitude 97° 51′ 03.82″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Mosley	234 52 13.30	55 00 48.97	4.4669171
Jim Ned	255 42 02.15	75 49 20.60	4.3239329

Primary Traverse.

In April and May, 1901, Mr. W. M. Beaman, topographer, ran a line of primary traverse southward from Bell Mountain triangulation station across the Fredericksburg and Boerne quadrangles, and connecting with the Boerne triangulation station, a linear distance of 61 miles. Three hundred and seventy transit stations were occupied, from which the following 29 geographic positions were computed:

Geographic positions along highways between Bell Mountain triangulation station and Waring.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Bell Mountain triangulation station	30 26 47.45	98 43 00.12
Fredericksburg, 14¼ miles northeast of, at forks of Bell Mountain-Fredericksburg and Bell Mountain-Willow City roads; bench-mark post, elevation 1,749 feet	30 24 40.4	98 43 44.9
Fredericksburg, 12¼ miles northeast of, at forks of Bell Mountain-Fredericksburg and Willow City-Fredericksburg roads; bench-mark post, elevation 1,826 feet	30 22 58.1	98 44 03.2
Fredericksburg, 9½ miles northeast of, north side of road near bend in fence; bench-mark post, elevation 1,953 feet	30 21 37.2	98 46 10.8
Fredericksburg, 8 miles northeast of, center of road opposite a galvanized stock tank	30 21 23.0	98 46 34.6
Fredericksburg, 6½ miles northeast of, 60 feet east of gate to Grobes's ranch; bench-mark post, elevation 1,724 feet	30 19 45.7	98 47 57.0
Fredericksburg, 4¼ miles northeast of, north side of road 650 feet northeast of Palo Alto Creek; bench-mark post, elevation 1,649 feet	30 18 28.8	98 48 55.2

Geographic positions along highways between Bell Mountain triangulation station and Waring—Continued.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Fredericksburg, 2¾ miles northeast of, at forks with a settlement road running northward; bench-mark post, elevation 1,824 feet	30 17 34.6	98 50 01.1
Fredericksburg, county court-house, southeast front of; bronze tablet, elevation 1,708 feet	30 16 30.2	98 52 17.1
Fredericksburg, forks of Fredericksburg-Burnet and Fredericksburg-Comfort lower roads; temporary bench mark on telephone pole, elevation 1,665 feet	30 16 08.7	98 51 23.9
Fredericksburg, 2¼ miles southeast of, on Comfort lower road; temporary bench mark, east side of road and 3 feet from fence, elevation 1,685 feet	30 14 14.9	98 50 49.9
Fredericksburg, 3 miles southeast of; milestone at forks of Fredericksburg-Austin, and lower Fredericksburg-Comfort roads, elevation 1,613 feet	30 14 31.4	98 50 28.6
Fredericksburg, 5 miles southeast of; gate southwest forks of settlement and Comfort lower road	30 13 39.1	98 50 25.8
Fredericksburg, 5¼ miles southeast of; culvert between fences	30 12 19.4	98 50 08.2
Pedernales and South Grape creeks, summit of Fredericksburg and Comfort lower road between	30 10 07.1	98 49 17.3
Comfort-Luckenback and Comfort-Fredericksburg lower roads, at forks of; iron bench-mark post, elevation 1,784 feet	30 09 02.5	98 49 04.4
Gillespie and Kendall County line, stone post west side of road	30 08 33.8	98 49 03.6
Block and South Grape creeks, summit of Fredericksburg-Comfort lower road between	30 06 05.0	98 49 10.7
Forks of Comfort lower road and lane westward to Giles ranch; bench-mark post, elevation 1,611 feet	30 04 04.5	98 49 42.6
Comfort and Waring road forks, at bend in road, 1¼ miles north of; bench-mark post, elevation 1,453 feet	30 01 53.0	98 49 58.6
Comfort and Waring road forks; temporary bench mark at milestone, elevation 1,415 feet	30 00 42.0	98 50 02.6
Fredericksburg-Waring and Fredericksburg-Sisterdale road forks; iron bench-mark post, elevation 1,553 feet	29 59 41.0	98 40 04.5

Geographic positions along San Antonio and Aransas Pass Railroad.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Waring, road crossing 300 feet north of	29 57 01.2	98 48 16.0
Road crossing, 60 feet north of milepost 281	29 56 22.5	98 47 18.3
Welfare, water tank	29 54 27.2	98 47 08.9
Public road crossing, 1,135 feet north of milepost 278	29 53 57.4	98 47 06.0
Road under railroad, one-third mile north of mile post 276	29 52 31.1	98 46 18.3
Milepost 273	29 49 45.2	98 45 42.2

Geographic positions between Boerne City and Boerne triangulation station.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Boerne, intersection of Main street and street to Boerne Hotel	29 47 30.9	98 43 54.2
Boerne, 1 mile southwest of; middle of lane, roads to Boerne, Bandera, and Balcones ranch	29 46 45.3	98 44 14.6
Boerne, triangulation station	29 45 27.24	98 45 30.75

MONTANA.

Secondary Triangulation Stations.

In the fall of 1900 Mr. R. H. Chapman added two new stations—Hospital and Columbia—to the local scheme at Butte, and a new station was established at Walkerville within a few feet of the site of the former one.

From these and other stations, including many "three-point" locations, numerous mines, shaft houses, tunnel mouths, and gallows frames, 100 points in all, were located in the vicinity of Butte in order to give accurate control for underground-mine maps.

The positions given are from preliminary computations only, no figure or station adjustment having been made.

HOSPITAL, SILVERBOW COUNTY.

On long smooth western slope of East Ridge, about one-fourth mile nearly due south from Boston and Montana Hospital, and 923 feet from northwest corner of collar of Atlantic shaft, which bears N. 118° 34′ 30″ E.

Station mark: An aluminum tablet cemented in granite block 30 by 8 by 8 inches, set 24 inches in the ground.

[Latitude 46° 01′ 38.36″. Longitude 112° 29′ 41.96″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Three (Roadway)	22 02 11	202 01 24	3.59033
Walkerville	119 04 42	299 03 05	3.52146
Columbia	298 35 53	118 36 12	3.30127
Southeast Base	346 34 52	166 35 16	3.48214

COLUMBIA, SILVERBOW COUNTY.

On rocky hill about 1 mile north of Columbia Garden, on first ridge south of Horse Canyon. It is the highest point on ridge west of road from Homestake mine to Columbia Garden, and about three-fourths mile west from mine.

Station mark: An aluminum tablet cemented in rock in place.

[Latitude 46° 01′ 07.36″. Longitude 112° 28′ 20.29″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Three (Roadway)	50 31 01	230 29 13	3.62009
Big Butte	92 46 56	272 43 12	3.82855
Walkerville	118 55 19	298 52 43	3.72625
Hospital	118 36 12	298 35 53	3.30127

WALKERVILLE, SILVERBOW COUNTY.

On low summit covered with granite bowlders, one-fourth mile north of brick schoolhouse at Walkerville, and one-half mile northeast of shaft house at Alice mine. Elevation 6,463.

Station mark: An aluminum tablet cemented in granite bowlder just north (25 feet approximate) of prospect hole on "First Stake" claim and about 250 feet east of Butte-Stringtown road.

[Latitude 46° 02′ 30.66″. Longitude 112° 31′ 57.02″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Big Butte	42 36 51	222 35 32	3.48500
Columbia	298 52 43	118 55 19	3.72625
Hospital	299 03 05	119 04 42	3.52146
Southeast Base	321 39 35	141 41 36	3.76493

"TUNNEL 10" PROSPECT, SILVERBOW COUNTY.

Prospect hole on highest point of hill southwest from Tunnel 10, Montana Central Railway. The ridge is a spur from "East Ridge" and is cut through by the railway tunnel.

Center of prospect hole is 4.5 feet east from position given.

[Latitude 46° 01′ 28.06″. Longitude 112° 28′ 40.08″.]

Mines located near Butte.

Name of mine.	Point located.	Latitude.	Longitude.
		° ′ ″	° ′ ″
Gopher	West post of gallows frame	46 00 51.77	112 31 05.04
Nora	West post of gallows frame	46 00 53.63	112 31 03.01
Iduna	West post of gallows frame	46 00 47.73	112 31 09.02
Shaft at northeast corner of South Gaylord and East Mercury streets.	Middle of gallows frame	46 00 51.16	112 31 12.88
Westlake	North post of gallows frame	46 00 51.38	112 31 09.37
Shaft on lot east of No. 432 East Park street.	East post of gallows frame	46 00 54.72	112 31 37.62
Oneida	East post of gallows frame	46 00 50.06	112 30 47.04
Pat Wall & Co	West post of gallows frame	46 00 47.76	112 30 45.99
Neva	West post of gallows frame	46 00 47.25	112 30 42.75
Bell	Center of gallows frame	46 01 35.96	112 31 22.80
Shaft at northeast corner of North Atlantic and East Galena streets.	West post of gallows frame	46 00 53.55	112 31 24.36
Monita	West post of gallows frame	46 00 48.07	112 30 53.07
West Stewart	West post of gallows frame	46 01 12.88	112 32 07.27
Anaconda	Middle of gallows frame	46 01 11.08	112 31 24.71
Diamond	Flagstaff over shaft	46 01 36.96	112 31 27.63
Neversweat	Middle of gallows frame	46 01 08.84	112 31 34.02
J. I. C	Middle of gallows frame	46 00 43.71	112 31 00.32
Little Rosa	Middle of gallows frame	46 01 01.45	112 31 25.52
Widow Reed (owner)	Middle of gallows frame	46 01 00.06	112 31 02.65
St. Lawrence	Middle of gallows frame	46 01 08.75	112 31 11.26
St. Lawrence	Middle of big ventilator	46 01 11.94	112 31 11.40
Mine south of Mountain View.	Middle of gallows frame	46 01 11.58	112 31 06.06
Boston and Montana No. 7.	Middle of gallows frame	46 01 05.74	112 29 14.63
Belmont	Ventilator shaft	46 00 48.23	112 31 20.42

Mines located near Butte—Continued.

Name of mine.	Point located.	Latitude.	Longitude.
		° ′ ″	° ′ ″
Modoc	Middle of hood on shaft house.	46 01 31.27	112 30 49.92
West Colusa	Middle of gallows frame	46 01 23.74	112 30 43.04
Minnie Healy	Middle frame over southeast shaft.	46 01 18.13	112 30 32.50
Minnie Healy	Middle frame over northwest shaft.	46 01 18.85	112 30 33.51
Leonard	Flagstaff	46 01 22.21	112 30 30 92
East Colusa	Middle comb on shaft house.	46 01 26.49	112 30 25.27
Bordeaux	Middle of gallows frame	46 01 28.93	112 30 02.80
Speculator	Middle of gallows frame	46 01 39.52	112 31 09.61
L. E. R	Middle of gallows frame	46 01 17.20	112 31 26.07
Humboldt	Ventilator	46 01 23.94	112 32 19.19
Buffalo	Middle comb on shaft house.	46 01 29.64	112 32 12.50
Mountain Con No. 2	Flagstaff	46 01 30.70	112 31 56.48
West Grayrock	Intersection of gables on shaft house.	46 01 42.14	112 31 44.21
Green Mountain	Flagstaff	46 01 33.37	112 31 41.90
Wake-up-Jim	Middle comb on shaft house.	46 01 33.20	112 31 35.52
Nipper	Middle frame of vertical shaft.	46 01 14.22	112 31 44.07
Nipper	Middle frame at top of incline shaft.	46 01 14.98	112 31 46.74
Little Mina	South ventilator	46 01 17.96	112 31 50.78
Gagnon	Flagstaff	46 01 08.84	112 32 19.53
Josephine	Middle of west gallows frame	46 01 49.00	112 31 58.99
Magna Charta	Flagstaff	46 02 07.02	112 31 56.26
Lilly	Middle of gallows frame	46 01 07.98	112 28 58.70
"Doc" Wierhurst (owner).	Stack, tunnel south of Columbia garden.	46 00 17.40	112 27 29.06
Valdemere	Flagstaff	46 02 06.02	112 31 44.25
Moose	Flagstaff	46 02 01.46	112 31 40.46
East Grayrock	Flagstaff	46 01 38.32	112 31 30.76
Poulin	Flagstaff	46 01 26.93	112 32 23.94
Highore No. 2	Middle of gallows frame	46 01 26.22	112 31 09.52
Ramsdell Parrot	Peak of gallows frame	46 01 06.36	112 31 37.67
Colusa Parrot	Flagstaff	46 01 06.31	112 31 40.02
Sirius	Middle of gallows frame	46 01 32.12	112 30 30.34
Balaklava	Middle of gallows frame	46 01 34.30	112 30 38.54
Mountain Chief	Middle of gallows frame	46 01 36.50	112 30 39.82
Sioux Chief	Middle of gallows frame	46 01 39.36	112 30 51.90
Old Joe (fraction)	Ventilator	46 01 39.02	112 31 00.96
Adirondack	Middle of gallows frame	46 01 41.20	112 31 09.14

Mines located near Butte—Continued.

Name of mine.	Point located.	Latitude.	Longitude.
		° ′ ″	° ′ ″
Tycoon	Middle of gallows frame	46 01 42.74	112 31 17.12
Speculator No. 6	Middle of gallows frame	46 01 41.92	112 31 25.40
Gem	Ventilator	46 01 48.44	112 30 54.71
Wild Bill	Middle of gallows frame	46 01 42.94	112 31 27.50
Cora (east)	Ventilator	46 01 47.46	112 31 38.14
Atlantic	Northwest corner of shaft collar.	46 01 33.87	112 29 30.57
Star	Middle comb of shaft house	46 01 28.29	112 32 18.08
Tramway	Ventilator	46 01 11.82	112 30 32.70
Mountain View	Middle of gallows frame	46 01 16.55	112 31 05.76
Parnell	Middle of gallows frame	46 01 20.67	112 31 19.92
Stewart	Middle of gallows frame	46 01 13.00	112 31 53.56
Original	Flagstaff	46 01 08.66	112 32 16.68
Parrot	Middle of gallows frame	46 01 06.98	112 31 35.85
Washoe	Middle of cupola	46 01 04.95	112 31 57.58
Bluejay	Middle of gallows frame	46 01 02.65	112 31 48.52
Moonlight	Middle of gallows frame	46 01 01.31	112 31 32.74
Sarsfield	Middle of gallows frame	46 01 00.32	112 28 53.00
Bellona	Middle of gallows frame	46 01 01.92	112 31 36.96
Amazon	Middle of gallows frame	46 00 22.36	112 28 51.40
Altona	Middle of gallows frame	46 00 21.02	112 28 46.04
Homestake	Ventilator	46 01 25.38	112 27 57.53
Clinton	Boiler stack at tunnel	46 01 29.32	112 27 50.12
B. & M. No. 4	Middle of gallows frame	46 01 38.29	112 30 06.54
Sinbad	Middle of gallows frame	46 01 23.28	112 29 16.30
Bill Moran (owner)	Middle of gallows frame	46 00 11.22	112 28 39.60
Glass Bros	Middle frame of shaft	46 00 43.48	112 30 09.48
Barus	Vertical bolt in middle of stay frame east of shaft.	46 01 07.24	112 30 43.41
Glengary	Middle of gallows frame	46 00 44.60	112 30 41.80
Shaft west of south of Anaconda mine.	Middle of ventilator	46 01 04.28	112 31 28.25
Mine southeast of Neversweat shaft.	Middle of gallows frame	46 01 06.03	112 31 31.01
Silverbow	Ventilator	46 00 53.90	112 30 42.20
Silverbow No. 3	Flagstaff	46 00 44.59	112 30 36.28
Berkeley	Flagstaff	46 01 02.12	112 30 37.10
Pennsylvania	Middle of gallows frame	46 00 59.28	112 30 58.77

UTAH-WYOMING.

Triangulation Stations.

The following stations form a belt of quadrilaterals which starts from a line of the United States Coast and Geodetic Survey station Deseret-Nebo, and extends northeasterly and then easterly along the forty-first parallel of latitude through the Uinta Forest Reserve. Nine of these stations were published in the Nineteenth and the remainder in the Twentieth Annual Report of the United States Geological Survey. All the positions have been recomputed and based on the "U. S. Standard" datum, and are now republished with corrected values.

NEBO, JUAB COUNTY, UTAH.

[Latitude 39° 48′ 39.11″. Longitude 111° 45′ 56.92″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Deseret	134 47 27.68	314 14 12.20	5.0118874
Timpanogos	189 49 32.25	9 54 33.61	4.8107167
Spanish Fork Peak	213 26 56.70	33 36 08.50	4.5674464

DESERET, TOOELE COUNTY, UTAH.

[Latitude 40° 27′ 35.30″. Longitude 112° 37′ 32.55″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Timpanogos	275 20 54.42	95 59 25.06	4.9264460
Spanish Fork Peak	293 28 17.08	114 10 51.86	5.0092198
Nebo	314 14 12.20	134 47 27.68	5.0118874

TIMPANOGOS, UTAH COUNTY, UTAH.

[Latitude 40° 23′ 04.92″. Longitude 111° 38′ 09.04″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Nebo	9 54 33.61	189 49 32.25	4.8107167
Deseret	95 59 25.06	275 20 54.42	4.9264460
Clayton	195 47 43.75	15 50 42.67	4.3766781
Kamas	227 15 07.05	47 32 13.42	4.7032109
Currant Creek Peak	270 51 37.53	91 09 34.01	4.5932849
Spanish Fork Peak	344 15 55.66	164 20 08.53	4.5840282

SPANISH FORK PEAK, UTAH COUNTY, UTAH.

[Latitude, 40° 05′ 17.46″. Longitude, 111° 31′ 37.56″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Nebo	33 36 08.50	213 26 56.70	4.5674464
Deseret	114 10 51.86	293 28 17.08	5.0092198
Timpanogos	164 20 08.53	344 15 55.66	4.5340282
Kamas	202 33 01.42	22 45 51.01	4.8616269
Currant Creek Peak	222 51 16.76	43 04 57.11	4.6439550
Strawberry	275 25 26.49	95 46 24.82	4.6678909
Grey Head	280 38 47.23	101 10 20.60	4.8518116
Indian Head	293 26 04.72	113 50 13.17	4.7662870

CURRANT CREEK PEAK, WASATCH COUNTY, UTAH.

[Latitude, 40° 22′ 42.51″. Longitude, 111° 10′ 27.48″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Spanish Fork Peak	43 04 57.11	222 51 16.76	4.6439550
Timpanogos	91 09 34.01	270 51 37.53	4.5932849
Clayton Peak	125 59 02.55	305 44 02.70	4.6050691
Wanship	154 05 48.90	333 53 53.12	4.7704972
Kamas	176 49 22.38	356 48 28.80	4.5431299
Grey Head	318 55 39.11	139 13 38.95	4.7815030
Peak	323 24 40.00	143 40 47.00	4.7763501
Strawberry	336 10 21.58	156 17 45.70	4.6040241

CLAYTON PEAK, AT CORNER OF SUMMIT, SALT LAKE, AND WASATCH COUNTIES, UTAH.

[Latitude 40° 35′ 27.46″. Longitude 111° 33′ 33.48″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Timpanogos	15 50 42.67	195 47 43.75	4.3766781
Wanship	192 51 38.26	12 54 45.17	4.4792754
Porcupine	218 28 39.76	38 46 17.17	4.7836351
Kamas	249 40 20.57	69 54 29.61	4.5137508
Currant Creek Peak	305 44 02.70	125 59 02.55	4.6050691

KAMAS, SUMMIT COUNTY, UTAH.

[Latitude 40° 41′ 33.01″. Longitude 111° 11′ 49.91″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Spanish Fork Peak	22 45 51.01	202 33 01.42	4.8516269
Timpanogos	47 32 13.42	227 15 07.05	4.7032109
Clayton Peak	69 54 29.61	249 40 20.57	4.5137508
Wanship	127 18 26.73	307 07 22.51	4.4763953
Porcupine	191 28 34.44	11 32 00.20	4.5674671
Medicine Butte	198 17 51.24	18 29 16.19	4.8880062
La Motte Peak	256 19 48.60	76 37 15.85	4.5880839
Currant Creek Peak	356 48 28.80	176 49 22.38	4.5431299

WANSHIP, ON BOUNDARY LINE BETWEEN SUMMIT AND MORGAN COUNTIES.

[Latitude 40° 51′ 20.24″. Longitude 111° 28′ 46.97″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Clayton Peak	12 54 45.17	192 51 38.26	4.4792754
Medicine Butte	220 51 58.21	41 14 32.92	4.8645769
Porcupine	239 44 46.60	59 59 19.11	4.5565221
Elizabeth Mountain	257 40 58.82	78 10 26.43	4.8101140
La Motte Peak	278 08 42.73	98 37 16.48	4.7931848
Kamas	307 07 22.51	127 18 26.73	4.4763953
Currant Creek Peak	333 53 53.12	154 05 48.90	4.7704972

PORCUPINE, SUMMIT COUNTY, UTAH.

[Latitude 40° 01′ 06.39″. Longitude 111° 06′ 35.38″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Kamas	11 32 00.20	191 28 34.44	4.56746
Clayton Peak	38 46 17.17	218 28 39.76	4.78363
Wanship	59 59 19.11	239 44 46.60	4.5565
Medicine Butte	204 31 22.53	24 39 22.57	4.6109
Elizabeth Mountain	278 01 22.26	98 16 19.18	4.508
La Motte Peak	311 49 13.93	132 03 18.71	4.608

LA MOTTE PEAK, SUMMIT COUNTY, UTAH.

[Latitude 40° 46′ 26.67″. Longitude 110° 45′ 05.04″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Kamas	76 37 15.85	256 19 48.60	4.5880839
Wanship	98 37 16.48	278 08 42.73	4.7931848
Porcupine	132 03 18.71	311 49 13.93	4.6085751
Medicine Butte	168 31 24.33	348 25 15.56	4.8168173
Elizabeth Mountain	184 33 11.98	4 34 02.28	4.3547610
Bridger Butte	202 30 52.24	22 42 12.37	4.7989716
Gilbert Peak	260 50 54.64	81 07 03.28	4.5463910

ELIZABETH MOUNTAIN, SUMMIT COUNTY, UTAH.

[Latitude 40° 58′ 38.09″. Longitude 110° 43′ 48.18″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
La Motte Peak	4 34 02.28	184 33 11.98	4.3547610
Wanship	78 10 26.43	257 40 58.82	4.8101140
Porcupine	98 16 19.18	278 01 22.26	4.5089383
Medicine Butte	160 25 21.23	340 18 21.14	4.6461719
Bridger Butte	212 05 39.46	32 16 10.43	4.6282448
Sage Creek	248 57 50.75	69 21 36.34	4.7341364
Gilbert Peak	297 15 45.93	117 31 06.26	4.5688482

MEDICINE BUTTE, UINTA COUNTY, WYO.

[Latitude 41° 21′ 09.90″. Longitude 110° 54′ 26.39″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Kamas	18 29 16.19	198 17 51.24	4.8880052
Porcupine	24 39 22.57	204 31 22.53	4.6109744
Wanship	41 14 32.92	220 51 58.21	4.8645769
Bridger Butte	279 15 39.35	99 33 14.11	4.5758129
Gilbert Peak	320 44 12.65	141 06 35.92	4.8789648
Elizabeth Mountain	340 18 21.14	160 25 21.23	4.6461719
La Motte Peak	348 25 15.56	168 31 24.33	4.8168173

BRIDGER BUTTE, UINTA COUNTY, WYO.

[Latitude 41° 17′ 50.40″. Longitude 110° 27′ 49.07″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
La Motte Peak	22 42 12.37	202 30 52.24	4.7989716
Elizabeth Mountain	32 16 10.43	212 05 39.46	4.6232448
Medicine Butte	99 33 14.11	279 15 39.35	4.5758129
Sage Creek	299 51 00.03	120 04 18.12	4.5126707
Gilbert Peak	348 44 47.41	168 49 40.71	4.7293086

GILBERT PEAK, ON LINE BETWEEN WASATCH AND SUMMIT COUNTIES, UTAH.

[Latitude 40° 49′ 25.45″. Longitude 110° 20′ 22.56″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
La Motte Peak	81 07 03.28	260 50 54.64	4.5463910
Elizabeth Mountain	117 31 06.26	297 15 45.93	4.5688482
Medicine Butte	141 06 35.92	320 44 12.65	4.8789648
Bridger Butte	168 49 40.71	348 44 47.41	4.7293086
Sage Creek	206 07 18.94	26 15 40.40	4.6073643
Turtle Bluff	218 40 53.40	38 51 45.65	4.5701299
Widdop	235 56 47.98	56 07 25.77	4.4393071
Phil Pico	244 49 20.32	65 05 47.90	4.5907433
North Burro	260 49 03.06	80 55 32.98	4.1507944
Leidy Peak	278 00 01.68	98 19 51.90	4.6349144
Marsh Peak	285 57 57.66	106 18 00.22	4.6528536

SAGE CREEK, UINTA COUNTY, WYO.

[Latitude 41° 09′ 03.30″. Longitude 110° 07′ 38.02″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
North Burro	6 35 39.39	186 33 49.02	4.5354837
Gilbert Peak	26 15 40.40	206 07 18.94	4.6073643
Elizabeth Mountain	69 21 36.34	248 57 50.75	4.7341364
Bridger Butte	120 04 18.12	299 51 00.03	4.5126707
Phil Pico	318 43 47.07	138 51 55.70	4.4210797
Turtle Bluff	323 48 45.24	143 51 16.87	3.9597700
Widdop	346 50 12.14	166 52 29.89	4.3331520

TURTLE BLUFF, UINTA COUNTY, WYO.

[Latitude 41° 05′ 04.76″. Longitude 110° 03′ 47.44″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Widdop	2 03 07.42	182 02 53.73	4.1342101
Gilbert Peak	38 51 45.65	218 40 53.40	4.5701299
Sage Creek	143 51 16.87	323 48 45.24	3.9597700
Phil Pico	316 05 50.87	136 11 27.82	4.2382357
Milepost 314	344 06 02.80	164 07 20.11	4.0021400
Milepost 315	353 18 40.62	173 19 12.48	3.9883851

WIDDOP, SUMMIT COUNTY, UTAH.

[Latitude 40° 57′ 43.48″. Longitude 110° 04′ 08.30″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
North Burro	34 01 37.55	213 57 30.09	4.1992517
Gilbert Peak	56 07 25.77	235 56 47.98	4.4393071
Sage Creek	166 52 29.87	346 50 12.14	4.3331520
Turtle Bluff	182 02 53.73	2 03 07.42	4.1342101
Milepost 314	219 22 54.67	39 24 25.56	3.7081856
Phil Pico	264 46 20.88	84 52 11.10	4.0983480
Leidy Peak	317 12 08.38	137 21 22.82	4.4661622

NORTH BURRO, SUMMIT COUNTY, UTAH.

[Latitude 40° 50′ 38.23″. Longitude 110° 10′ 26.23″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gilbert Peak	80 55 32.98	260 49 03.06	4.1507944
Sage Creek	186 33 49.02	6 35 39.39	4.5354837
Widdop	213 57 30.09	34 01 37.55	4.1992517
Phil Pico	236 11 30.26	56 21 27.54	4.4093534
Leidy Peak	286 08 29.01	106 21 49.80	4.4759231

MILEPOST 315, UTAH-WYOMING.

[Latitude 40° 59′ 51.29″. Longitude 110° 02′ 58.92″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Turtle Bluff	173 19 12.48	353 18 40.62	3.9883851
Milepost 314	269 50 10.40	89 50 55.84	3.2092432
Phil Pico	284 27 35.04	104 32 39.87	4.0500968

UINTA, SWEETWATER COUNTY LINE, INITIAL POINT, WYOMING.

[Latitude 40° 59′ 51.30″. Longitude 110° 02′ 54.85″.]

MILEPOST 314, UTAH-WYOMING.

[Latitude 40° 59′ 51.43″. Longitude 110° 01′ 49.65″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Widdop	39 24 25.56	219 22 54.67	3.7081856
Milepost 315	89 50 55.84	269 50 10.40	3.2092432
Turtle Bluff	164 07 20.11	344 06 02.80	4.0021400
Phil Pico	286 53 46.33	106 58 05.74	3.9851925

PHIL PICO, UINTA COUNTY, UTAH.

[Latitude 40° 58′ 20.18″. Longitude 109° 55′ 14.14″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
North Burro	56 21 27.54	236 11 30.26	4.4093534
Gilbert Peak	65 05 47.90	244 49 20.32	4.5907433
Widdop	84 52 11.10	207 28 30.66	4.0983480
Milepost 315	104 32 39.87	284 27 35.04	4.0500968
Milepost 314	106 58 05.74	286 53 46.33	3.9851925
Turtle Bluff	136 11 27.82	316 05 50.87	4.2382357
Sage Creek	138 51 55.70	318 43 47.07	4.4210797
Twin Buttes	218 14 15.28	38 22 46.53	4.4668992
Richards Butte	264 33 43.03	84 57 58.50	4.7166557
Lena	295 34 16.38	115 54 08.97	4.6754428
Trout Creek Peak	318 53 50.69	139 02 11.33	4.4358754
Leidy Peak	342 00 22.18	162 03 47.16	4.3762588
Marsh Peak	344 53 55.73	164 57 33.64	4.4774312

LEIDY PEAK, UINTA COUNTY, UTAH.

[Latitude 40° 46′ 06.79″. Longitude 109° 50′ 00.89″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gilbert Peak	98 19 51.90	278 00 01.68	4.6349144
North Burro	106 21 49.80	286 08 29.01	4.4759231
Widdop	137 21 22.82	317 12 08.38	4.4661622
Phil Pico	162 03 47.16	342 00 22.18	4.3762588
Trout Creek Peak	259 02 24.06	79 07 19.08	4.0329170
Lena	266 32 16.83	86 48 42.36	4.5495441
Marsh Peak	355 47 36.34	175 47 49.36	3.8050251

MARSH PEAK, UINTA COUNTY, UTAH.

[Latitude 40° 42′ 40.42″. Longitude 109° 49′ 40.94″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gilbert Peak	106 18 00.22	285 57 57.66	4.6528536
Phil Pico	164 57 33.64	344 53 55.73	4.4774312
Leidy Peak	175 47 49.36	355 47 36.34	3.8050251
Twin Buttes	191 16 48.14	11 21 39.70	4.7243835
Trout Creek Peak	230 15 37.15	50 20 18.97	4.1194058
Richards Butte	232 26 46.63	52 47 20.28	4.7448761
Lena	256 18 37.30	76 34 49.24	4.5554878
Little Mountain	330 16 33.05	150 21 36.00	4.3440832

TROUT CREEK PEAK, UINTA COUNTY, UTAH.

[Latitude 40° 47′ 13.03″. Longitude 109° 42′ 29.19″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Marsh Peak	50 20 18.97	230 15 37.15	4.1194058
Leidy Peak	79 07 19.08	259 02 24.06	4.0329170
Phil Pico	139 02 11.33	318 53 50.69	4.4358754
Little Mountain	358 21 41.82	178 22 03.68	4.4410184

TWIN BUTTES, SWEETWATER COUNTY, WYO.

[Latitude 41° 10′ 45.54″. Longitude 109° 42′ 16.05″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Marsh Peak	11 21 39.70	191 16 48.14	4.7243825
Phil Pico	38 22 46.53	218 14 15.28	4.4668992
Richards Butte	298 20 57.24	118 36 44.26	4.5826379
Lena	330 38 27.97	150 49 52.43	4.6983833

RICHARDS BUTTE, SWEETWATER COUNTY, WYO.

[Latitude 41° 00′ 54.25″. Longitude 109° 18′ 15.37″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Lena	20 10 09.52	200 05 49.86	4.4308414
Marsh Peak	52 47 20.28	232 26 46.63	4.7448761
Phil Pico	84 57 58.50	264 33 43.03	4.7166557
Twin Buttes	118 36 44.26	298 20 57.24	4.5826379

LENA, UINTA COUNTY, UTAH.

[Latitude 40° 47′ 13.44″. Longitude 109° 24′ 51.94″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Little Mountain	41 08 57.10	220 57 50.04	4.5636299
Marsh Peak	76 34 49.24	256 18 37.30	4.5554878
Leidy Peak	86 48 42.36	266 32 16.83	4.5495441
Phil Pico	115 54 08.97	295 34 16.38	4.6754428
Twin Buttes	150 49 52.43	330 38 27.97	4.6983833
Richards Butte	200 05 49.86	20 10 09.52	4.4308414

LITTLE MOUNTAIN, UINTA COUNTY, UTAH.

[Latitude 40° 32′ 18.40″. Longitude 109° 41′ 55.65″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Marsh Peak	150 21 36.00	330 16 33.05	4.3440832
Trout Creek Peak	178 22 03.68	358 21 41.82	4.4410184
Lena	220 57 50.04	41 08 57.10	4.5636299

STRAWBERRY, WASATCH COUNTY, UTAH.

[Latitude 40° 02′ 50.21″. Longitude 110° 59′ 02.69″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Spanish Fork Peak	95 46 24.82	275 25 26.49	4.6678909
Currant Creek Peak	156 17 43.70	336 10 21.58	4.6040241
Grey Head	290 42 49.22	110 53 25.10	4.3996083
Peak	300 11 14.91	120 19 59.04	4.3501804
Indian Head	339 20 18.91	159 23 31.16	4.3044758

INDIAN HEAD, NEAR THE COUNTY LINE BETWEEN UTAH AND WASATCH COUNTIES, UTAH.

[Latitude 39° 52′ 38.52″. Longitude 110° 54′ 03.36″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Spanish Fork Peak	113 50 13.17	293 26 04.72	4.7662870
Strawberry	159 23 31.16	339 20 18.91	4.3044758
Peak	238 13 36.16	58 19 07.32	4.1587604
Grey Head	238 39 17.42	58 46 40.08	4.2825707

GREY HEAD, WASATCH COUNTY, UTAH.

[Latitude 39° 58′ 01.24″. Longitude 110° 42′ 33.58″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Indian Head	58 46 40.08	238 39 17.42	4.2825707
Peak	60 04 27.00	240 02 36.00	3.6772294
Spanish Fork Peak	101 10 20.60	280 38 47.23	4.8518116
Strawberry	110 53 25.10	290 42 49.22	4.3996083
Currant Creek Peak	139 13 38.95	318 55 39.11	4.7815030

PEAK (SECONDARY POINT), WASATCH COUNTY, UTAH.

[Latitude 39° 56′ 44.28″. Longitude 110° 45′ 27.22″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Indian Head	58 19 07.3	238 13 36.1	4.1587604
Strawberry	120 19 59.0	300 11 14.9	4.3501804
Currant Creek Peak	143 40 47.0	323 24 40.0	4.7763501
Grey Head	240 02 36.0	60 04 27.0	3.6772294

WYOMING, SOUTHWEST CORNER STONE.

[Latitude 40° 59′ 53.48″. Longitude 111° 02′ 56.67″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Porcupine	112 50 36	292 48 06	3.7638576

PACIFIC SECTION OF TOPOGRAPHY.

IDAHO.

Triangulation Stations.

In order to control the Coeur d'Alene mining district triangulation was extended eastward from Chilco and Skalan in June, 1900, by Mr. C. F. Urquhart, topographer. Five new stations were occupied.

STEVENS, SHOSHONE COUNTY.

On line between Shoshone County, Idaho, and Missoula County, Mont., on a well-known mountain about 5 miles south of Mullan, Idaho. There is a good trail from Mullan to the station.

Station mark: The lone signal tree, about 45 feet south of highest point of mountain.

Reference mark: A copper bolt marked "U. S. G. S." set in solid rock 45 feet from signal tree. Azimuth from signal to bolt 167° 45′.

[Latitude 47° 25′ 29.39″. Longitude 115° 46′ 26.26″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Latour	91 27 22.97	271 01 20.43	4.6481338
Kellogg	104 51 23.76	284 35 39.87	4.4432141
Chilco	132 37 45.67	312 04 10.16	4.8864328
Rocky	143 44 46.29	323 30 47.10	4.6028676
Murray	170 37 01.65	350 34 28.86	4.4233365

MURRAY, SHOSHONE COUNTY.

(Not occupied.)

On highest point of mountain 3 miles north of Murray and reached by a trail from that town.

Station mark: A copper bolt set in solid rock, over which is a rock monument.

[Latitude 47° 39′ 36.10″. Longitude 115° 49′ 53.36″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Kellogg	49 43 18.52	229 30 05.72	4.4693979
Latour	58 01 20.20	237 37 47.52	4.6748654
Rocky	107 36 27.05	287 24 59.43	4.3082328
Chilco	116 22 22.58	295 51 16.67	4.7665873

ROCKY, SHOSHONE COUNTY.

(Not occupied.)

The highest point of a high, rocky mountain, on north fork of Coeur d'Alene River.

Station mark: Summit of peak.

[Latitude 47° 42′ 54.21″. Longitude 116° 05′ 23.22″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Kellogg	6 49 33.70	186 47 47.23	4.4047370
Latour	33 25 24.87	213 13 17.95	4.5736341
Skalan	81 37 53.23	260 57 58.06	4.8349247
Chilco	120 48 15.23	300 28 37.39	4.5849139
Murray	287 24 59.43	107 36 27.05	4.3082328
Stevens	323 30 47.10	143 44 46.29	4.6028676

KELLOGG, SHOSHONE COUNTY.

A well-known mountain about 3 miles south from Wardner, reached by a good trail from that town.

Station mark: The lone fir signal tree on northeast end of summit.

Reference mark: A copper bolt marked "U. S. G. S." set in rock 20.1 feet from signal tree. Azimuth from tree to bolt is 89° 25′.

[Latitude 47° 29′ 17.77″. Longitude 116° 07′ 47.40″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Latour	71 00 10.77	250 49 51.40	4.2702192
Skalan	103 15 21.92	282 37 17.47	4.8222362
Chilco	146 13 00.71	325 55 11.60	4.7324703
Rocky	186 47 47.23	6 49 33.70	4.4047370
Murray	229 30 05.72	49 43 18.52	4.4693979
Stevens	284 35 39.87	104 51 23.76	4.4482141

LATOUR, KOOTENAI COUNTY.

On the highest peak of the high mountain near the head of Latour Creek, about 3 miles south of the well-known point called "Baldy." There is a trail up Latour Creek to mouth of Rocky Creek, thence up ridge on north side of Rocky Creek, around the head of same to station.

Station mark: A copper bolt marked "U. S. G. S." set in solid rock, surmounted by a rock monument 7 feet in height.

[Latitude 47° 26′ 00.54″. Longitude 116° 21′ 48.00″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Skalan	114 11 17.60	293 43 34.19	4.7128285
Chilco	166 07 57.68	346 00 30.41	4.7197069
Rocky	213 13 17.95	33 25 24.87	4.5736341
Murray	237 37 47.52	58 01 20.20	4.6748654
Kellogg	250 49 51.40	71 00 10.77	4.2702192
Stevens	271 01 20.43	91 27 22.97	4.6481338

WASHINGTON.

Triangulation Stations.

Triangulation in north-central Washington was extended westward from the 119th meridian to the 120th meridian, controlling four 30-minute quadrangles and connecting the work based upon the Spokane astronomic station and base with that based upon Ellensburg. Six new and five old stations were occupied during the season of 1900 by Mr. C. F. Urquhart, topographer.

KELLER, FERRY COUNTY.

On the highest point on range of mountains about 7 miles (air line) west from Keller post-office. To reach station take trail from Keller to Nespalem, and at 7 miles from former take trail running northwest up small dry creek, thence up the ridge.

Station mark: A fir tree about 50 feet high, trimmed up.

Reference mark: A copper bolt set in large rock (18 or 20 feet high) 33.6 feet north of tree.

[Latitude 48° 03′ 39.93″. Longitude 118° 47′ 48.89″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Salt Lake	108 05 26.64	287 31 18.60	4.7760002
Omach	138 42 51.92	318 19 52.78	4.7601759
Moses	150 19 12.87	330 07 19.51	4.5994835
Paint Rock	208 13 28.45	28 26 41.31	4.6646604
Whitestone	281 30 34.12	101 43 20.40	4.3380503

TONK, OKANOGAN COUNTY.

On the highest point of mountain on the north side of Tonk Creek, a small stream that empties into the Okanogan River, a little south from Riverside post-office. The station can be easily reached from the south side, which is covered with bunch grass nearly to the summit.

Station mark: A lone fir tree 18 feet high about 20 feet north of highest point.

Reference mark: A copper bolt marked "U. S. G. S." set in large rock 17.6 feet S. 3° E. from tree.

[Latitude 48° 32′ 43.23″. Longitude 119° 14′ 15.36.″]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Omach	26 40 32.95	206 37 16.77	4.0787940
Bonaparte	197 27 31.35	17 32 39.77	4.4663412
Fir	238 59 51.86	59 13 24.89	4.4128438
Moses	326 08 28.00	146 16 19.39	4.3666952

OMACH, OKANOGAN COUNTY.

On the highest peak on ridge between Tonk and Omach creeks, at the head of Similkin Creek, a small stream flowing into the Okanogan River parallel to Omach Creek. The peak is about 6 miles east of the Okanogan River and can best be ascended from the south and west sides. All timber has been cut from the summit of mountain.

Station mark: A copper bolt marked "U. S. G. S." set in solid rock, above which a rock monument was erected.

[Latitude 48° 26′ 56.31″. Longitude 119° 18′ 37.30″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Salt Lake	36 49 35.99	216 38 22.64	4.4918667
Buck	88 04 23.29	267 41 20.68	4.5811673
Lemanasky	144 50 59.09	324 36 59.53	4.6022378
Bonaparte	200 10 04.43	20 18 29.15	4.6001909
Tonk	206 37 16.77	26 40 32.95	4.0787940
Fir	228 50 52.45	49 07 41.26	4.5631331
Moses	295 04 43.11	115 15 50.06	4.3066980
Keller	318 19 52.78	138 42 51.92	4.7601759

SALT LAKE, OKANOGAN COUNTY.

On a low timbered hill 5 or 6 miles east from Molett, on west side of Okanogan River and 13 miles southeast from Alma post-office and ferry. The hill is the highest point in the immediate vicinity and has salt lakes on every side of it.

Station mark: A pine tree trimmed up for signal.

Reference mark: A copper bolt marked "U. S. G. S." set in solid rock 21 feet west from tree.

[Latitude 48° 13′ 31.03″. Longitude 119° 33′ 38.62″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	Meters.
Buck	140 12 24.31	320 00 28.29	4.4854816
Omach	216 38 22.64	36 49 35.99	4.4918667
Moses	246 04 17.57	66 26 36.30	4.6060805
Keller	287 31 18.60	108 05 26.64	4.7760002

LEMANASKY, OKANOGAN COUNTY.

On the highest point on ridge between the Okanogan River and Sinlohegan Creek, about 17 miles from Conconully and 8 miles south from Loomis. The road from Conconully to Lemanasky Lake goes within 2 miles of mountain. All timber has been cut from summit except on north side.

Station mark: A bronze tablet cemented in solid rock, above which was erected a rock cairn 7 feet high.

[Latitude 48° 44′ 34.06″. Longitude 119° 37′ 24.94″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	Meters.
Buck	23 39 30.89	203 30 26.39	4.5703951
Tiffany	70 24 16.66	250 10 17.61	4.3847799
Chapaca (2)	156 58 50.42	336 53 14.31	4.3661596
Bonaparte	262 31 57.97	82 54 31.81	4.5689617
Fir	279 28 30.68	99 59 28.98	4.7102014
Moses	314 42 29.04	135 07 42.81	4.7669900
Omach	324 36 59.53	144 50 59.09	4.6022378

CHAPACA (2), OKANOGAN COUNTY.

(Not occupied.)

A sharp rocky peak 8 or 10 miles a little north of west from Loomis; the flat ridge about 2 miles west is higher.

Station mark: Summit of peak.

[Latitude 48° 56′ 06.12″. Longitude 119° 44′ 51.38″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Lemanasky	336 53 14.31	156 58 50.42	4.3661596
Tiffany	24 54 10.88	204 45 46.51	4.5128241

BUCK, OKANOGAN COUNTY.

A round, timbered mountain, locally known as Buck Mountain, on the divide between Okanogan and Methow rivers. It is the most southeastern high point on ridge and is at the head of Johnson and Sweat creeks. The road between Twisp and Conconully passes about 4 miles south from station at the point where it crosses Sweat Creek, 17 miles from Twisp. From this point horses can be ridden to station. It is difficult to reach from north and west sides.

Station mark: The lone pine signal tree, 20 feet high.

Reference mark: An aluminum bolt, marked "U. S. G. S.," set in rock. Azimuth from tree 134° 09′, distance 5.9 feet.

[Latitude 48° 26′ 10.72″. Longitude 119° 49′ 30.94″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Lookout	63 07 29.09	242 51 10.72	4.4804841
Tiffany	162 50 58.70	342 46 05.81	4.4331645
Lemanasky	203 30 26.39	23 39 30.89	4.5703951
Bonaparte	232 53 29.34	53 25 04.68	4.8106748
Fir	248 30 00.29	69 09 58.40	4.8473307
Omach	267 41 20.68	88 04 23.29	4.5811673
Moses	276 59 28.07	97 33 41.19	4.7552967
Salt Lake	320 00 28.29	140 12 24.31	4.4854816

TIFFANY, OKANOGAN COUNTY.

A round, bare, double-topped mountain, lying in the main range between the Okanogan and Methow rivers at the head of Boulder Creek, which is the first tributary of any size of the Chewach River above Winthrop. The station is on the higher and more southerly summit of mountain.

Station mark: A hole drilled 6 inches deep in solid rock on highest point, over which was erected a rock cairn 8 feet high.

[Latitude 48° 40′ 09.23″. Longitude 119° 56′ 01.69″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Lookout	25 32 01.12	205 20 33.59	4.6423317
Chapaca (2)	204 45 46.51	24 54 10.88	4.5128241
Lemanasky	250 10 17.61	70 24 16.66	4.3847799
Moses	296 53 56.32	117 33 05.90	4.8595761
Buck	342 46 05.81	162 50 58.70	4.4331645

LOOKOUT, OKANOGAN COUNTY.

A round-topped, bunch-grass hill, partly timbered on northwest slope, lying on west side of Methow River between Twisp and Lydle creeks, about 10 miles, by trail, from Twisp post-office.

Station mark: An aluminum bolt, stamped "U. S. G. S.," set in drill hole in solid rock, surmounted by a small rock monument.

[Latitude 48° 18′ 46.18″. Longitude 120° 11′ 19.79″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Tiffany	205 20 33.59	25 32 01.12	4.6423317
Buck	242 51 10.72	63 07 29.09	4.4804841

CENTRAL CALIFORNIA (SIERRA FOREST RESERVE).

Triangulation Stations.

Three 30-minute quadrangles in the high Sierras were controlled during the summer of 1900 by Mr. E. T. Perkins, jr., topographer, who extended triangulation southward from Mounts Conness, Lyell, Hoffman, and Devil. In addition to reoccupying these, 10 new stations were occupied and numerous prominent peaks located by intersection.

Positions published herewith are based upon the 1901 United States standard datum of the Coast and Geodetic Survey.

CONNESS, MONO COUNTY.

A primary station of the Coast and Geodetic Survey 10 miles north of Soda Springs. In shape, an irregular parallelogram of granite, from northwest portion of which rises the top of peak with precipitous side of 1,000 feet or more. It can be ascended from Soda Springs in

four hours by a trail built by the Coast and Geodetic Survey. Grass and water can be found within 1 mile of summit.

Station mark: Concrete pier with five-eighths-inch copper bolt in center.

[Latitude 37° 58′ 02.59″. Longitude 119° 19′ 14.23″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Red	12 36 41.02	192 33 26.59	4.5515767
Clarks Peak	17 29 05.74	197 25 09.01	4.4979644
Devil	37 22 32.54	217 07 08.88	4.7855483
Hoffman	51 21 09.23	231 14 10.79	4.3288340
Cottonwood Peak	83 06 44.80	262 51 29.07	4.5639041
Dana	310 11 57.93	130 15 39.67	4.0621370
Lyell	350 09 07.63	170 10 57.54	4.4088947

DANA, TUOLUMNE COUNTY.

A large, bare, somewhat irregular peak, with cone-shaped top, covered with broken sandstone and granite.

Station mark: Stone monument about 6 feet high.

[Latitude 37° 54′ 00.88″. Longitude 119° 13′ 13.53″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Lyell	14 01 13.38	193 59 22.02	4.2637680
Clarks Peak	39 02 46.85	218 55 09.22	4.4630003
Hoffman	77 04 59.75	256 54 20.18	4.4171931
Conness	130 15 39.67	310 11 57.93	4.0621370

HOFFMAN, TUOLUMNE COUNTY.

About 2 miles west of Lake Tenaya and 39 miles from Sequoia, on the west of Tioga road. The mountain has three sharp ridges of granite and the point occupied is the highest and farthest west. On this ridge is Chimney Rock, a cylinder of granite rising from main ledge to height of 60 feet, and it is north of this that station occupied is situated.

Station mark: A cross cut in rock, over which was erected a monument 5 feet high.

[Latitude 37° 50′ 50.13″. Longitude 119° 30′ 35.94″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Devil	29 59 03.70	209 50 37.68	4.6092431
Pilot	76 06 02.86	255 50 24.41	4.5866541
Cottonwood	114 13 51.81	294 05 35.56	4.3358253
Conness	231 14 10.79	51 21 09.23	4.3268340
Dana	256 54 20.18	77 04 59.75	4.4171931
Lyell	299 28 12.89	119 37 00.01	4.3886744
Clarks Peak	336 34 41.61	156 37 42.36	4.2597926
Red	337 23 09.91	157 26 52.71	4.2654986

DEVIL, MARIPOSA COUNTY.

At the southeast end of short, sharp ridge, 9 miles southwest of Wawona Park, bare on top and covered with loose rock. Ascended by wagon road from Wawona. Nearest camping place is 1¼ miles northeast of summit.

Station mark: A cairn of stones, 4 feet base, 4½ feet high, on site of old monument, 5.6 feet west of "U. S. G. S." chiseled on rock.

[Latitude 37° 31′ 46.80″. Longitude 119° 44′ 23.06″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pilot	146 23 49.18	326 16 39.63	4.4928478
Cottonwood	180 37 19.76	00 37 31.81	4.6445464
Hoffman	209 50 37.68	29 59 03.70	4.6092431
Conness	217 07 08.88	37 22 32.54	4.7855484
Clarks Peak	235 55 55.04	56 07 20.30	4.5212361
Red	244 35 09.78	64 47 16.70	4.5097490
Kaiser	297 47 02.53	118 07 16.04	4.7451616
Big Shuteye	305 41 47.10	125 53 10.71	4.5325137

LYELL, MONO COUNTY.

Situated 14 miles southeast of Soda Springs, at end of Tuolomne Meadows. In shape very irregular. The south side is a nearly perpendicular wall, the north a series of meadows until the glacier is reached; the east and west sides are rather steep. The highest point is a short, sharp ridge, about 200 yards long, running northwest and southeast, the northwest end being lower. Ascended from head of Lyell Fork and northeast side of peak.

Station mark: Small stone monument; "U. S. G. S." chiseled on rock east of it.

[Latitude 37° 44′ 23.22″. Longitude 119° 16′ 15.15″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Big Shuteye	17 46 48.27	197 41 04.96	4.6571504
Red	52 03 35.82	231 58 32.37	4.1882294
Clarks Peak	71 03 13.41	250 57 27.71	4.1654618
Hoffman	119 37 00.01	299 28 12.89	4.3836744
Conness	170 10 57.54	350 09 07.63	4.4088947
Dana	198 59 22.02	14 01 13.38	4.2637680
Silver	323 29 17.71	143 38 27.25	4.5704983
Kaiser	351 13 21.55	171 16 30.07	4.6987072

RED, MADERA COUNTY.

Ascended from camp at large meadows south of Merced Peak, on trail from Wawona to Soda Springs (or "77" corral), five hours by trail. Could camp much nearer at head of Illilouette River and climb the mountain in three hours. Approached mountain from west, apparently the best way. Can take mules to within 2,000 feet of top.

Station mark: A bronze triangulation tablet set between two large rocks, over which is erected a cairn of rocks 5 feet at base, 7 feet high.

[Latitude 37° 39′ 15.31.″ Longitude 119° 24′ 31.41″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Big Shuteye	2 48 05.05	182 47 24.19	4.5289143
Devil	64 47 16.70	244 35 09.78	4.5097490
Hoffman	157 26 52.71	337 23 09.91	4.3654986
Conness	192 33 26.59	12 36 41.02	4.5515767
Lyell	231 58 32.37	52 03 35.82	4.1882294
Silver	300 40 31.80	120 54 43.33	4.6010921
Kaiser	333 32 06.49	153 40 16.75	4.6487389

BIG SHUTEYE, MADERA COUNTY.

On the bare granite summit of Big Shuteye Peak (Chiquito Peak), the highest point on Chiquito Range, at southeast end of the ridge. Follow trail from Jackass Meadows to where it crosses ridge, then turn to south.

Station mark: A bronze triangulation tablet cemented in solid granite, above which is erected a cairn of rocks 4 feet base and 4 feet high.

[Latitude 37° 21′ 00.26″. Longitude 119° 25′ 38.53″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Devil	125 53 10.71	305 41 47.10	4.5325137
Red	182 47 24.19	2 48 05.05	4.5289143
Lyell	197 41 04.96	17 46 48.27	4.6571504
Silver	249 33 51.80	69 48 41.16	4.5842369
Hilgard	268 29 47.16	88 51 40.06	4.7264787
Kaiser	285 51 29.47	106 00 18.72	4.3498243
Three Sisters	305 14 15.24	125 27 35.30	4.6014728

SILVER, FRESNO COUNTY.

On the highest peak between Fish Creek and Mono Creek, at head of Silver Creek. Summit is flat, running north-northeast and south-southwest. Highest point is at southwest end. Can camp at meadows below Margaret Lakes; thence it is three and one-half hours' travel to station. Can take mules within 700 feet of summit on east. There is grass and water for one night within 1,200 feet of summit.

Station mark: A bronze triangulation tablet set in solid rock, on which was erected a cairn of rocks 5 feet base and 5 feet high.

[Latitude 37° 28′ 12.56″. Longitude 119° 01′ 14.54″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Three Sisters	5 29 45.00	185 28 18.92	4.5635462
Kaiser	36 48 49.60	216 42 50.78	4.3855104
Big Shuteye	69 48 41.16	249 33 51.80	4.5842369
Red	120 54 43.33	300 40 31.80	4.6010921
Lyell	143 38 27.25	323 29 17.71	4.5704983
Hilgard	305 02 47.29	125 09 52.52	4.3230108

KAISER, FRESNO COUNTY.

On a bald peak at the head of Kaiser and Pittman creeks. It is easily ascended from south side. There are numerous lakes and small meadows in the neighborhood.

Station mark: A bronze triangulation tablet set in loose earth, there being no solid rock, above which was erected a cairn of rocks 5 feet base and 5 feet high.

[Latitude 37° 17′ 41.24″. Longitude 119° 11′ 05.57″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Big Shuteye	106 00 18.72	285 51 29.47	4.3493243
Red	153 40 16.75	333 32 06.49	4.6487389
Lyell	171 16 30.07	351 13 21.55	4.6987072
Silver	216 42 50.78	36 48 49.60	4.3855104
Hilgard	256 50 47.29	77 03 50.04	4.5135451
Goddard	237 01 21.12	117 18 14.22	4.6669912
Three Sisters	326 51 09.06	146 55 40.62	4.3067670

HILGARD, FRESNO COUNTY.

Ascended peak from camp on Bear Creek; five and one-half hours' travel. Could camp an hour closer by going to summit of ridge between Bear Creek and Mono Creek. This mountain is best approached along the ridge between Bear and Mono creeks, finally dropping down into northeast fork of Bear Creek and climbing peak from east. On summit of this peak are three small high points of rock. The point occupied is the one to north, or center one.

Station mark: A large flat rock, on which is set a bronze triangulation tablet surmounted by a cairn of rocks 3 feet base and 3 feet high.

[Latitude 37° 21′ 40.11″. Longitude 118° 49′ 34.65″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Three Sisters	40 31 08.67	220 22 39.06	4.5049242
Kaiser	77 03 50.04	256 50 47.29	4.5135451
Big Shuteye	88 51 40.06	268 29 47.16	4.7264787
Silver	125 09 52.52	305 02 47.29	4.3230108
Goddard	341 35 56.51	161 39 49.34	4.4786204

THREE SISTERS, FRESNO COUNTY.

On the south end of summit of the Three Sisters. Can be reached by trail between Shaver and Blaney Meadow (or Hot Springs). Leave trail at large meadow between Red Mountain and Potato Hill, traveling southeast. At foot of mountain on northeast side is a small meadow with running water. Animals can be taken nearly to summit from south to southeast.

Station mark: A bronze triangulation tablet set in loose rock, with a cairn of rocks built over it 3 feet at base and 3 feet high.

[Latitude 37° 03' 30.59". Longitude 119° 03' 36.59".]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ' "	° ' "	*Meters.*
Big Shuteye	125 27 35.30	305 14 15.24	4.6014728
Kaiser	146 55 40.62	326 51 09.06	4.3067670
Silver	185 28 18.92	5 29 45.00	4.5635462
Hilgard	220 22 39.06	40 31 03.67	4.5049242
Goddard	277 50 59.53	98 03 19.88	4.4854257
Silliman	329 28 41.38	149 41 47.00	4.8062708
Big Baldy	342 58 38.44	163 05 03.75	4.7858215

GODDARD, FRESNO COUNTY.

Ascended peak by ridge running from the southwest up from camp on south fork of San Joaquin, at pasture 1½ miles above the camp of the Mount Goddard Copper Mining Company. Can take animals within 1,500 feet of summit. The south end of the mountain was occupied, although the north end is slightly higher. The south end seems to be the recognized summit and is much easier of access.

Station mark: A bronze triangulation tablet set in loose shale rock, over which is erected a cairn of rocks 4 feet base and 4 feet high.

[Latitude 37° 06' 13.35". Longitude 118° 43' 09.82".]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ' "	° ' "	*Meters.*
Big Baldy	16 54 10.44	196 48 19.23	4.6987440
Three Sisters	98 03 19.88	277 50 59.53	4.4854257
Kaiser	117 18 14.22	297 01 21.12	4.6669912
Hilgard	161 39 49.34	341 35 56.51	4.4786204
Silliman	357 42 48.51	177 43 37.67	4.7076974

SILLIMAN, TULARE COUNTY.

Highest point in group on west end of ridge. Best reached from camp at Wet Meadows; cross low divide east, follow up creek to first lake, then climb on south side of ridge. Can take mules to top of first point; then one and one-half hours' climb to summit. Good camp at Wet Meadows, from which it is four hours' climb to summit.

Station mark: A bronze triangulation tablet set in solid rock, over which is a cairn of rocks 6 feet base and 6 feet high.

[Latitude 36° 38′ 39.71″. Longitude 118° 41′ 47.89″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Big Baldy	100 48 39.50	280 42 01.26	4.2269529
Three Sisters	149 41 47.00	329 28 41.38	4.8062703
Goddard	177 43 37.67	357 42 48.51	4.7076974

SPANISH, FRESNO COUNTY.

Spanish Mountain can be easily ascended either from Statum or Collins Meadows by riding about two hours.

Station mark: A bronze triangulation tablet set in top of granite rock, over which is erected a cairn of rocks 3 feet base and 3 feet high.

[Latitude 36° 54′ 35.21″. Longitude 118° 53′ 27.21″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Three Sisters	149 43 36.33	329 37 29.39	4.4747072
Goddard	215 17 45.76	35 23 57.36	4.4213575

BIG BALDY, TULARE COUNTY.

Ascended from camp at Woodard's cabin by trail. Time of ascension one hour. Top of mountain is a bare ridge about 200 yards long. Tops of trees growing on the side of hill interfere somewhat with view. South end of hill occupied.

Station mark: A bronze triangulation tablet set in solid rock, and a rock cairn erected over it 7 feet base and 10 feet high. A tree about 15 feet high placed in monument.

[Latitude 36° 40′ 21.81″. Longitude 118° 52′ 54.94″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Three Sisters	163 05 03.75	342 58 38.44	4.7358215
Goddard	196 48 19.23	16 54 10.44	4.6987440
Silliman	280 42 01.26	100 48 39.50	4.2269529

SOUTHERN CALIFORNIA.

Triangulation Stations.

Triangulation in southern California was extended northward and westward from Santa Clara and San Fernando stations of the United

States Coast and Geodetic Survey and connected with two other stations of the same organization—Gaviota and Tepusquet—all based on Yolo base data. Nine new primary stations were occupied and 7 secondary points located by intersections, controlling three 30-minute quadrangles between latitudes 34° 30′ and 35° 00′ and longitudes 118° 30′ and 120° 00′.

The field work was done by Mr. C. F. Urquhart, topographer, during portions of May, June, November, and December, 1900.

LIEBRE, LOS ANGELES COUNTY.

On the highest point of a high, round mountain, sometimes known as Sawmill Mountain, near the east end of the Liebre Range. The mountain is covered with brush about 5 feet high. The new road from Elizabeth Lake to Gorman station passes about 4 miles north from the station at a point 9 miles from former. A trail leaves the road about 1 mile west from Joe Kirby's shack and goes south to summit of an open ridge, from which signal can be seen.

Station mark: An oak tree wired up and used as signal.

Reference mark: A copper bolt marked "U. S. G. S." set in solid rock. Azimuth from reference mark to signal tree 13° 42′; distance 6 feet.

[Latitude 34° 40′ 53.35″. Longitude 118° 34′ 38.63″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
San Fernando	3 13 38.57	183 12 49.60	4.5938706
Hines	67 27 48.01	247 10 48.77	4.6952879
Frazier	105 59 53.39	285 46 28.84	4.5723919
Alamo	72 59 13.47	252 49 16.46	4.4457065

SAN FERNANDO, LOS ANGELES COUNTY.

A station of the United States Coast and Geodetic Survey, on the highest or western crest of San Fernando Mountain, about 5 miles from the long tunnel of the Southern Pacific Railroad.

Station mark: A terra-cotta pipe 24 by 4 inches filled with concrete and set in a triangle of concrete.

[Latitude 34° 19′ 41.47″. Longitude 118° 36′ 05.08″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Santa Clara	89 28 35.36	269 13 45.80	4.6056340
Hines	114 50 26.99	294 34 21.17	4.6815183
Frazier	145 43 47.71	325 31 15.76	4.7772296
Liebre	183 12 49.60	3 13 38.57	4.5938706

ALAMO, LOS ANGELES COUNTY.

(Not occupied.)

A high, rocky mountain near the eastern end of the Alamo Range, sometimes known as Bowlder Peak. It can be reached by trail from the Alamo ranch around by Mr. Bailey's ranch, which is about 6 miles south from the road between Elizabeth Lake and Gorman station, at a point 5 miles from the latter.

Station mark: A small tree on highest point of the mountain.

[Latitude 34° 36′ 27.04″. Longitude 118° 52′ 05.92″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Santa Clara	26 38 24.17	206 32 35.20	4.5460392
Frazier	153 16 34.07	333 13 12.39	4.3146687
Liebre	252 49 16.46	72 59 13.47	4.4457065
San Fernando	321 33 54.87	141 42 58.66	4.5967546

FRAZIER, VENTURA COUNTY.

On the highest point of a mountain locally known as Frazier Mountain, in the northeastern corner of Ventura County, about 2 miles from the Los Angeles County line. The wagon road from Gorman station to Bakersfield passes about 4 miles from the station, at a point 4 miles from the former. There is a good trail from Gorman station to Frazier mine, which is near the triangulation station. Another trail from Cuddy's ranch to Frazier mine passes 100 yards north from station.

Station mark: A lone pine tree 100 feet north from the summit of the mountain.

[Latitude 34° 46′ 25.21″. Longitude 118° 58′ 10.93″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hines	18 24 44.23	198 21 06.61	4.4902268
Reyes	60 50 55.17	240 40 15.20	4.5157054
Pine	103 13 38.72	283 06 51.20	4.2706034
Liebre	285 46 28.84	105 59 53.39	4.5723919
San Fernando	325 31 15.76	145 43 47.71	4.7772296
Alamo	333 13 12.39	153 16 34.07	4.3146687

SANTA CLARA, VENTURA COUNTY.

A station of the United States Coast and Geodetic Survey, on the highest part of the mountain on the south side of Santa Clara River, about 2 miles in an air line from the town of Santa Paula.

Station mark: A terra-cotta pipe 24 by 4 inches filled with concrete and set in a triangle of concrete.

[Latitude 34° 19′ 26.69″. Longitude 119° 02′ 22.57″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hines	170 44 32.36	350 48 18.21	4.8181190
San Fernando	269 13 45.80	89 28 35.36	4.6056340

HINES, VENTURA COUNTY.

On the highest point of a mountain locally known as Hines Peak, near the source of Santa Paula Creek and on the divide between Santa Paula and Sespe creeks. The point is rather difficult to reach, though there is a trail up Santa Paula Creek to foot of mountain. It may be reached from the Hot Springs on Sespe Creek. The summit is cleared of brush.

Station mark: A bunch of brush about 7 feet high wired together and used as a signal.

Reference mark: A copper bolt marked “$\overset{\text{U.}}{\text{G.}}\triangle\overset{\text{S.}}{\text{S.}}$” set in solid rock 8.33 feet southwest from signal and station mark.

[Latitude 34° 30′ 33.01″. Longitude 119° 04′ 33.77″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Reyes	125 15 00.85	305 08 00.24	4.3640299
Pine	165 55 35.48	345 52 27.04	4.5394977
Frazier	198 21 06.61	18 24 44.23	4.4902268
Liebre	247 10 48.77	67 27 48.01	4.6952879
San Fernando	294 34 21.17	114 50 26.99	4.6815183
Santa Clara	350 43 18.21	170 44 32.36	4.8181190

PINE, VENTURA COUNTY.

On the highest point on western end of Pine Mountain, more generally known as San Amedia Mountain, which is the highest point in the county. There is an old signal, used by the Wheeler survey, on the east end of mountain about 1 mile from the station. There is a good trail from Mr. Cuddy's ranch to summit.

Station mark: A copper bolt marked “$\overset{\text{U.}}{\text{G.}}\triangle\overset{\text{S.}}{\text{S.}}$” set in loose rock, above which is a flat rock marked “$\overset{\text{U.}}{\text{G.}}+\overset{\text{S.}}{\text{S.}}$”

[Latitude 34° 48′ 43.09″. Longitude 119° 10′ 05.12″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Reyes	27 16 08.13	207 12 14.63	4.3577728
Santa Ynez	67 04 40.56	246 37 00.23	4.9075345
San Rafael	79 18 24.52	258 56 17.86	4.7800219
McPherson	98 13 30.47	277 51 22.50	4.7754341
Frazier	283 06 51.20	103 13 38.72	4.2706034
Hines	345 52 27.04	165 55 35.48	4.5394977

REYES, VENTURA COUNTY.

On the highest point of the divide between Sespe Creek and Cuyama River, about 8 miles northwest from Rafael Reyes's residence. A wagon road down Cuyama River goes to Mr. Reyes's residence, thence go by good trail to station. Another hill 100 yards north has timber on it and a line was cut through it in line with Pine station.

Station mark: A lone fir tree used as a signal.

Reference mark: A copper bolt marked “$\overset{\text{U.}}{\text{G.}}\triangle\overset{\text{S.}}{\text{S.}}$” set in a large rock 4.5 feet south from signal tree.

[Latitude 34° 37′ 45.47″. Longitude 119° 16′ 55.01″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Santa Ynez	79 59 25.73	259 35 41.90	4.8127423
San Rafael	100 28 41.94	280 10 31.52	4.6955497
McPherson	120 35 27.28	300 17 16.07	4.7517482
Pine	207 12 14.63	27 16 08.13	4.3577728
Frazier	240 40 15.20	60 50 55.17	4.5157054
Hines	305 08 00.24	125 15 00.85	4.3640299

MONTECITO, SANTA BARBARA COUNTY.

(Not occupied.)

The highest point in range of mountains, about 15 miles northeast from Santa Barbara and 12 miles west from Nordoff.

Station mark: A small tree on summit of mountain.

[Latitude 34° 32′ 16.09″. Longitude 119° 28′ 02.44″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Santa Ynez	88 28 44.70	268 11 26.42	4.6719106
Pine	221 57 31.18	42 07 44.09	4.6122972
Reyes	239 07 20.27	59 13 39.08	4.2968168

CUYAMA, VENTURA COUNTY.

(Not occupied.)

A prominent mountain on the south side of the Cuyama River, about 10 miles below Rafael Reyes's ranch.

Station mark: Highest point of mountain.

[Latitude 34° 45′ 09.39″. Longitude 119° 28′ 33.68″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
McPherson	115 53 33.34	295 42 03.73	4.5352838
Pine	256 45 41.17	76 56 13.56	4.4615707
Reyes	307 30 51.89	127 37 29.51	4.3509242

CALIENTE, SANTA BARBARA COUNTY.

(Not occupied.)

About 8 miles northwest from the Cuyama ranch, on the highest point of the white, barren mountains, on the north side of the Cuyama River.

Station mark: Highest point of mountain.

[Latitude 35° 02′ 05.42″. Longitude 119° 45′ 38.11″.]

To station—	Azimuth.	Back azimuth.	Log distance.
	° ′ ″	° ′ ″	*Meters.*
McPherson	16 29 20.48	196 27 31.05	4.2326250
Pine	294 22 31.13	114 42 52.23	4.7746474
Reyes	315 38 33.94	135 54 53.05	4.7977730

M'PHERSON, SANTA BARBARA COUNTY.

About 14 miles from the Cuyama ranch, on a high round mountain covered with brush about 4 feet high. A road goes from this ranch to Bart McPherson's house, from which there is a trail to foot of mountain. A long ridge leads to summit, which may be ascended on horseback. Station called "Peak," distant 2¾ miles a little north of east, is about 50 feet higher.

Station mark: The oak signal tree.

Reference mark: A copper bolt marked "$\substack{\text{U.}\\\text{G.}}\triangle\substack{\text{S.}\\\text{S.}}$" set in loose rock, with a rock marked "U. + S." placed over it. Azimuth from signal tree to reference mark 286° 41′; distance 9.5 feet.

[Latitude 34° 53′ 13.75″. Longitude 119° 48′ 49.08″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
San Rafael	0 12 48.02	180 12 46.38	4.2947312
Santa Ynez	20 43 12.35	200 37 33.66	4.6322557
Tepusquet	94 05 47.00	273 52 58.05	4.5341310
Pine	277 51 22.50	98 13 30.47	4.7754341
Reyes	300 17 16.07	120 35 27.28	4.7517482

SAN RAFAEL, SANTA BARBARA COUNTY.

On the northernmost of two rather flat mountains, the highest of the San Rafael Range. The point is rather difficult to reach. The best route is probably up Santa Cruz Creek from Santa Ynez Valley.

Station mark: A bronze triangulation tablet set in loose rock with a rock marked “$\overset{\text{U.}}{\text{G.}}$ ▲ $\overset{\text{S.}}{\text{S.}}$” above it, surmounted by a rock monument 7 feet high.

[Latitude 34° 42′ 34.06″. Longitude 119° 48′ 51.97″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Santa Ynez	36 30 39.52	216 25 03.23	4.4044042
Tepusquet	123 03 08.37	302 50 22.77	4.6087544
McPherson	180 12 46.38	0 12 48.02	4.2947312
Pine	258 56 17.86	79 18 24.53	4.7800219
Reyes	280 10 31.52	100 28 41.94	4.6955497

M'KINLEY, SANTA BARBARA COUNTY.

(Not occupied.)

A sharp, rocky peak, sometimes called McKinley Mountain. It can be reached from Los Olivos, from which point it shows as the highest point of the San Rafael Mountains.

Station mark: Highest point of mountain.

[Latitude 34° 42′ 03.28″. Longitude 119° 50′ 44.58″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Santa Ynez	32 09 03.51	212 04 27.73	4.3612394
Gaviota	55 37 39.82	235 25 34.91	4.5946496
Tepusquet	126 31 04.31	306 19 23.07	4.5889200
McPherson	188 04 46.00	8 05 51.91	4.3194832

PEAK, SANTA BARBARA COUNTY.

(Not occupied.)

This point is 2¼ miles a little north of west of primary station McPherson, and is the highest point on the range. It can be reached by traveling up the ridge westward from McPherson.

Station mark: Highest point of mountain.

[Latitude 34° 54′ 02.22″. Longitude 119° 51′ 33.00″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Santa Ynez	14 48 03.03	194 43 56.49	4.6337473
Tepusquet	91 47 18.72	271 36 03.44	4.4767463
McPherson	289 46 42.42	109 48 14.50	3.6458659
San Rafael	349 03 42.49	169 05 14.41	4.3343919

SANTA YNEZ, SANTA BARBARA COUNTY.

On the highest point of the Santa Ynez Range. It can be reached from the Santa Ynez Valley or the coast via new road from Los Olivos to Santa Barbara. From the valley on north side of mountains, go from Los Olivos or Santa Ynez to Mahoney's ranch, thence by road to the top of divide, thence east along the ridge 5 miles to station.

Station mark: A rock 2 by 4 feet, found in place, with a hole 2½ inches deep drilled in it.

[Latitude 34° 31′ 31.79″. Longitude 119° 58′ 43.93″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gaviota	82 11 19.18	262 03 49.90	4.3100387
Tepusquet	155 53 58.83	335 46 52.14	4.6681901
McPherson	200 37 33.66	20 43 12.35	4.6322557
San Rafael	216 25 03.23	36 30 39.52	4.4044042
Pine	246 37 00.23	67 04 40.56	4.9075345
Reyes	259 35 41.90	79 59 25.73	4.8127423

√ ZACA, SANTA BARBARA COUNTY.

(Not occupied.)

A point locally well known as Zaca Peak, about 10 miles east of north from Los Olivos.

Station mark: A small tree on summit.

[Latitude 34° 45′ 58.94″. Longitude 120° 01′ 26.79″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Tepusquet	136 40 59.81	316 35 23.85	4.3364840
McPherson	235 06 26.76	55 13 39.49	4.3702877
San Rafael	288 08 24.34	108 15 34.46	4.3056366
Santa Ynez	351 09 07.80	171 10 41.27	4.4320598

TEPUSQUET, SANTA BARBARA COUNTY.

A station of the United States Coast and Geodetic Survey on the highest peak of the Tepusquet Range. It can be reached from Goodchild's ranch in the Conyado Valley.

Station mark: A hole drilled in solid rock.

[Latitude 34° 54′ 30.98″. Longitude 120° 11′ 13.14.″]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gaviota	1 24 42.75	181 24 17.54	4.6561948
Gaviota (by C. & G. S.)	1 24 39.76	181 24 14.86	4.6561948
McPherson	273 52 58.05	94 05 47.00	4.5341810
San Rafael	302 50 22.77	123 03 08.37	4.6087544
Santa Ynez	335 46 52.14	155 53 58.83	4.6681901

GAVIOTA, SANTA BARBARA COUNTY.

A station of the United States Coast and Geodetic Survey on one of the highest peaks to the eastward of Gaviota Pass. The peak is best reached through the canyon extending toward the eastward from the pass at a distance of about 1 mile from the wharf. The highest peaks in the vicinity (between 150 and 300 feet higher) are situated 1½ miles to the eastward.

Station mark: A copper bolt set in concrete, above which a hollow cement pier is erected.

[Latitude 34° 30′ 01.01″. Longitude 120° 11′ 56.89″.]

(By Coast and Geodetic Survey, Yolo base data. Latitude 34° 30′ 00.83″. Longitude 120° 11′ 56.89.″)

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Tepusquet	181 24 17.54	1 24 42.45	4.6561948
Tepusquet (by Coast and Geodetic Survey)	181 24 14.86	1 24 39.76	4.6561948
Santa Ynez	262 03 49.90	82 11 19.18	4.3100387

ALASKA (NOME DISTRICT).

Triangulation Stations.

The following geographic positions are dependent on the positions of Grave and Round triangulation stations, as furnished by the United States Coast and Geodetic Survey.

The field work was done by Mr. R. B. Robertson, with a Saegmuller 4-inch vernier theodolite reading to 30″, under the direction of Mr. E. C. Barnard, topographer.

Average closure error of triangles, 11″.

ROCKY.

On highest point of a rocky peak about 7 miles N. 73° W. from Chinik. There is no trail to station, but it can be reached by going in a straight line from Chinik. There is good grass and water on west side about 1½ miles distant.

Station mark: + cut in solid rock, over which is a small pile of rock.

[Latitude 64° 34′ 24.84″. Longitude 162° 48′ 10.84″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Round	12 46 14.4	192 43 22.4	4.06137
Town	73 43 30.5	253 31 42.9	4.03657
Lime	121 47 26.3	301 16 49.3	4.50053
Grave	45 35 47.9	225 23 55.6	4.17143

ROUND.

A station of the Coast and Geodetic Survey on a rounded point, about 1 mile north of the island on which the astronomic station was situated. It is about 1,000 feet from the edge of the bluff.

Station mark: A cross cut in the center of top of a rock flush with surface of ground.

[Latitude 64° 28′ 22.10″. Longitude 162° 51′ 21.38″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Boot	86 39 02.9	266 22 28.0	4.16917
Grave	95 58 35.1	275 49 30.9	3.90852
Town	135 58 30.9	315 49 35.6	4.05584
Rocky	192 43 22.4	12 46 14.4	4.06137

NATURAL ROCK.

(Not occupied.)

A prominent rock on ridge between Golofnin Bay and Quinnehuk *River.*

[Latitude 64° 45′ 25.75″. Longitude 162° 51′ 40.00″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Town	18 01 39	197 53 00	4.39338
Rocky	352 15 06	172 18 15	4.31504

TOWN.

On sand spit at entrance to inner Golofnin Bay.

Station mark: Cross cut on large stone flush with surface of ground.

[Latitude 64° 32′ 45.81″. Longitude 163° 01′ 14.42″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Grave	1 02 53.9	181 02 44.8	3.86542
Boot	36 56 29.9	216 48 50.0	4.05432
Lime	139 56 55.1	319 38 06.5	4.40989
Rocky	253 31 42.9	73 43 30.5	4.03657
Round	315 49 35.6	135 58 30.9	4.05584

GRAVE.

A station of the Coast and Geodetic Survey on a high, grassy point about 300 meters from the end of a rocky point on the west side of the bay (Golofnin). There are several Eskimo graves near by.

Station mark: A cross cut in center of top of a large stone set flush with surface of ground.

[Latitude 64° 28′ 48.99″. Longitude 163° 01′ 24.47″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Town	181 02 44.8	1 02 53.9	3.86542
Rocky	225 23 55.6	45 35 47.9	4.17143
Round	275 49 30.9	95 58 35.1	3.90852

BOOT.

On highest part of ridge, about 7 miles S. 37° W. from Chinik. This ridge forms a narrow neck of land between Bering Sea and Golofnin Sound. It can be easily reached from any side on foot or with animals. There is plenty of water and some wood on the Golofnin side, and probably on other sides. There is a natural pile of rock

about 100 yards east of station. This is also a triangulation station of the United States Coast and Geodetic Survey.

Station mark: A rock monument.

[Latitude 64° 27′ 58.11″. Longitude 163° 09′ 43.96″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Monument	**124 07 51.5**	**303 39 15.6**	**4.48456**
Lime	**161 10 15.9**	**340 59 08.1**	**4.48186**
Town	**216 48 50.0**	**36 56 29.9**	**4.05432**
Round	**266 22 28.0**	**86 39 02.9**	**4.16917**

LIME.

On a white hill about 3½ miles N. 13° E. of a white hill near Fish River, known as White Mountain, and about the same distance from the town of White Mountain. The station is on the third white hill, counting from White Mountain north. There is little choice of a route to the station from White Mountain, but it is probably best to go via White Mountain and thence from one white hill to the other until station is reached. Wood and water are in abundance about one-half mile east of station.

Station mark: "U. + S." on rock, over which is a spruce tree about 15 feet high.

[Latitude 64° 43′ 19.55″. Longitude 163° 22′ 03.26″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Monument	52 59 57.6	232 42 27.9	4.28622
Solomon	80 25 55.1	259 46 11.9	4.55163
Council	123 11 55.0	302 49 05.0	4.37768
Rocky	301 16 49.3	121 47 26.3	4.50053
Boot	340 59 08.1	161 10 15.9	4.48186
Town	319 38 06.5	139 56 55.1	4.45989

WHITE MOUNTAIN.

(Not occupied.)

A low limestone hill about 200 feet above sea level on north bank of Fish River, one-fourth mile below town of White Mountain.

[Latitude 64° 40′ 41.11″. Longitude 163° 23′ 25.04″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Town	309 35 47	129 55 49	4.36198
Boot	335 12 39	155 25 01	4.41790

MONUMENT.

On highest point of ridge which runs north and east from Bluff City (Topkok), and about 4 miles N. 34° E. therefrom. A trail runs close to signal, coming from the south. It is easily accessible from Bluff City. There is good grass in the draws and water about 2 miles north of station.

Station mark: A rock monument about 9 feet high.

[Latitude 64° 37′ 02.65″. Longitude 163° 41′ 24.56″.]

To station—	Azimuth.	Back azimuth.	Log distance.
	° ′ ″	° ′ ″	*Meters.*
Solomon	105 53 38.2	285 31 15.7	4.31164
Council	169 19 13.2	349 13 54.1	4.39978
Lime	232 42 27.9	52 59 57.6	4.28622
Boot	303 39 15.6	124 07 51.5	4.48456

CHOWIK.

(Not occupied.)

A sharp peak about 3,500 feet above sea level, at head of Neukuluk River, Ophir Creek, and Parantulik River.

[Approximate position: Latitude 65° 08′ 34″. Longitude 163° 45′ 30″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Rocky	324 02 16	144 54 08	4.89170
Town	331 54 24	152 34 29	4.87628

COUNCIL.

A round, rocky point about 6 miles S. 42° W. of Council, being the nearest mountain south of Council.

Station mark: A rock marked "U. △ S.," above which is a rock monument 7 feet high, with a pine tree in the top.

[Latitude 64° 50′ 19.20″. Longitude 163° 47′ 17.57″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Solomon	38 13 07.7	217 56 03.3	4.38542
Lime	302 49 05.0	123 11 55.0	4.37768
Monument	349 13 54.1	169 19 13.2	4.39978

TOPKOK.

(Not occupied.)

On promontory by that name—a United States Coast and Geodetic Survey station.

[Latitude 64° 33′ 25.57″. Longitude 163° 57′ 53.22.″]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Solomon	151 46 10	331 38 26	4.14420
Monument	242 48 31	63 03 24	4.16949
Boot	284 35 16	105 18 44	4.60103

SOLOMON.

A high ridge, sometimes called Thomson Mountain, between the Right Branch and Big Hurrah Creek, both tributaries of Solomon River, and about 12 miles northeast of the mouth of Solomon River, but not visible therefrom. Ridge has three round points about the same height, the station being on the one which shows to be in the middle from nearly all directions. The point farthest west has two little natural humps on top. Station can be reached by going up Solomon River about 8 miles and thence across country a little north of east 8 or 9 miles. It is possible that it can be more easily reached from the mouth of Topkok River.

Station mark: "U. △ S." cut on rock in place, over which is a rock monument about 8 feet high.

[Latitude 64° 40′ 01.81″. Longitude 164° 06′ 10.18″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Council	217 56 03.3	38 13 07.7	4.38542
Monument	285 31 15.7	105 53 38.2	4.31164
Topkok	331 38 26.0	151 46 10.0	4.14420
Lime	259 46 11.9	80 25 55.1	4.55163

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PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Bulletin No. 181.]

The serial publications of the United States Geological survey consist of (1) Annual Reports, (2) Monographs, (3) Bulletins, (4) Mineral Resources, (5) Water-Supply and Irrigation Papers, (6) Topographic Atlas of United States—folios and separate sheets thereof, (7) Geologic Atlas of United States—folios thereof. A circular giving complete lists may be had on application.

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DEPARTMENT OF THE INTERIOR

BULLETIN

OF THE

UNITED STATES

GEOLOGICAL SURVEY

No. 182

SERIES A, ECONOMIC GEOLOGY, 12

WASHINGTON
GOVERNMENT PRINTING OFFICE
1901

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

A REPORT

ON THE

ECONOMIC GEOLOGY

OF THE

SILVERTON QUADRANGLE, COLORADO

BY

FREDERICK LESLIE RANSOME

WASHINGTON
GOVERNMENT PRINTING OFFICE
1901

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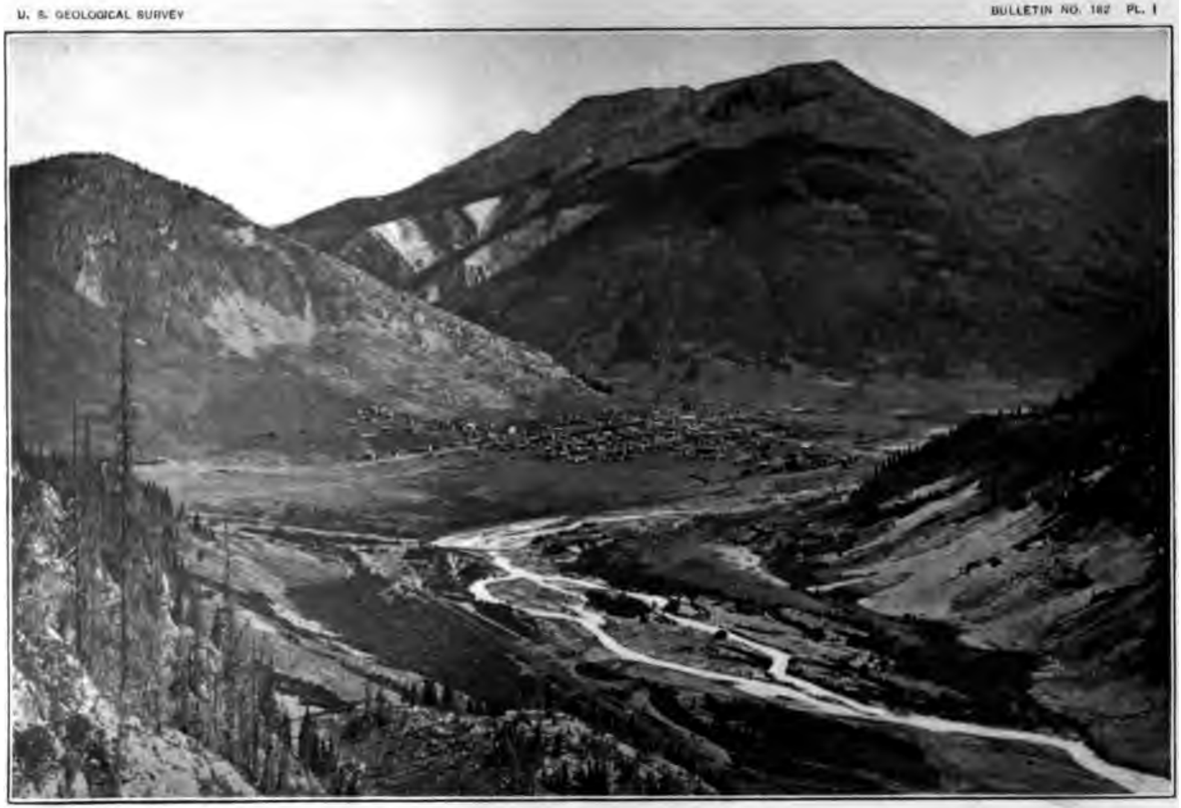


BAKERS PARK AND THE TOWN OF SILVERTON, FROM THE SOUTH.

On the left is Anvil Mountain, between Mineral and Cement creeks; in the background is Boulder Mountain, between Cement Creek and the Animas River. The three streams unite at Silverton and enter the gorge of the Animas near the lower right-hand corner of the picture. Photograph by

ECONOMIC GEOLOGY OF THE SILVERTON QUADRANGLE, COLORADO.

By F. L. Ransome.

PART I. GENERAL DESCRIPTION AND DISCUSSION OF THE ORE DEPOSITS.

INTRODUCTION AND ACKNOWLEDGMENTS.

The field work upon which this report is based occupied the season of 1899 from the beginning of July to the middle of October. During that summer nearly all of the area was examined and most of the mines and prospects were visited.

The work was resumed in the autumn of 1900, with Mr. Alfred M. Rock as assistant, a period of six weeks in August, September, and October being devoted to those portions of the quadrangle that had not been thoroughly studied in the preceding year and to an investigation of such mining developments as had been effected during the winter.

It was at one time hoped that the report of Mr. Whitman Cross, of this Survey, on the general geology of the Silverton quadrangle, forming the Silverton folio of the Geologic Atlas of the United States, might be published in advance of this investigation of the economic resources of the district, but owing to various causes his field work is not yet finished. I am therefore unable to use or to cite his results in their entirety, or to reproduce his geological map as an adjunct to this report. This is to be regretted, as both a thoroughly satisfactory treatment and a proper understanding of the ore deposits require a knowledge of the geological relationships of the rocks in which they lie. This want has been partly supplied by a brief preliminary sketch of the geology, kindly furnished by Mr. Cross. This is necessarily an imperfect outline, to be later replaced by his final results. To Mr. Cross I owe, also, the privilege of publishing a preliminary geological map (Pls. IV, V) of a portion of the area. This map is based upon field work done by himself and his assistants. The geological boundaries shown are not final and will undoubtedly be somewhat changed when the field work in this region is completed.

To Mr. S. F. Emmons, geologist in charge of the investigation of metalliferous deposits, my thanks are due for various helpful suggestions and criticisms and for access to his unpublished notes on the Yankee Girl and Guston mines.

The descriptions of the abandoned mines of the Red Mountain district would be far more imperfect than they are were it not for much information courteously supplied by Mr. Bedford McNeill, of London, liquidator of the New Guston Company; Mr. T. E. Schwarz, of Denver, and Mr. Otto J. Schulz, of St. Louis, trustee of the Genesee-Vanderbilt mines.

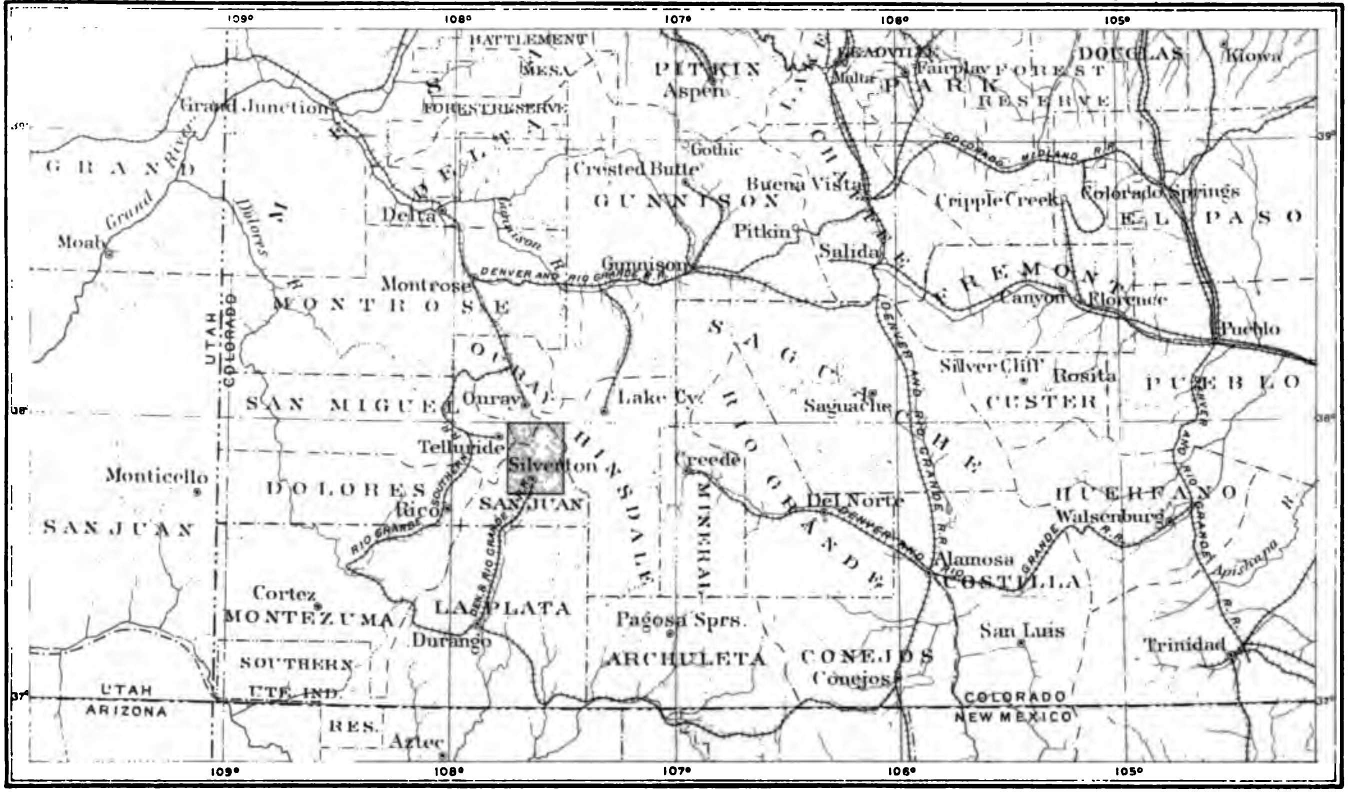
To the mining men of the region I am indebted for much cordial assistance and for courtesies which have many times been recalled with pleasure.

GEOGRAPHICAL POSITION.

The Silverton quadrangle, embracing one-sixteenth of a square degree of the earth's surface, lies between the meridians 107° 30′ and 107° 45′ west longitude and the parallels 37° 45′ and 38° 00′ north latitude. On the west it adjoins the Telluride quadrangle and on the south the Needle Mountain quadrangle. Its area is approximately 235.3 square miles. It lies in southwestern Colorado, in the highest and most rugged portion of the San Juan Mountains, including a part of the continental divide. There are comprised within its boundaries the headwaters of the Animas River and portions of the headwaters of the Rio Grande, Gunnison, Uncompahgre, and San Miguel rivers. The principal settlement is Silverton, a town of about 900 inhabitants. The position of the Silverton quadrangle with reference to the adjacent map units of the Geological Survey is shown in the index map, Pl. II.

LITERATURE.

The published literature relating to that portion of the San Juan Mountains included within the Silverton quadrangle is not voluminous. It is chiefly comprised in the official reports of the members of the Hayden survey, who visited the region in 1874, 1875, and 1876; in descriptive notes of various travelers through the San Juan; in scattered descriptions of mines and minerals occurring in the district, and in references to the history of mining development found in the more general works on Colorado and its resources. The following bibliography includes most of the important publications concerning the Silverton region. The data contained in them have been freely used in the preparation of the following historical sketch, for the purpose of supplementing information obtained at first hand from those who actually participated in the development of the district.



INDEX MAP SHOWING POSITION OF THE SILVERTON QUADRANGLE

Scale of miles

0 10 20 30 40 50 60 70 80 90 100

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Petrographical descriptions and chemical analyses of various more or less altered cimens from the southeastern quarter of the Silverton quadrangle.

HISTORICAL SKETCH.

Deeply covered with snow for a great part of the year, and standing remote from lines of transportation and points of supply, it is not surprising that the rugged San Juan Mountains should, until a comparatively late period, have discouraged the advance of prospectors into their lonely ravines. Prior to 1860 the area now included in the Silverton quadrangle had been visited by but few white men, and at a time when every gulch of the Sierra Nevada was a scene of picturesque activity the Indian and the mountain sheep were as yet undisturbed in their possession of the San Juan. But no natural obstacles have ever long withstood the restlessness and indomitable perseverance of the seekers after precious metals. In 1860 (according to some, 1861) a large party of miners, under the leadership of John Baker,[1] penetrated to the little mountain-rimmed "park" where the town of Silverton now stands. They had hoped to find profitable gulch mining, but, overtaken by the heavy winter snows and harassed by the Ute Indians, many of the party perished miserably and the remnant escaped over the mountains only after suffering great hardships. For several years the memory of this unfortunate expedition seems to have discouraged further attempts at prospecting in the neighborhood of Bakers Park. It was not until the early seventies that reports of mineral wealth again began to draw the more adventurous miners into the San Juan region. Some gold was early obtained by washing in Arrastra Gulch, and this led, in 1870, to the discovery by a party of prospectors sent out by Governor Pile, of New Mexico, of the first mine which was successfully operated, the Little Giant, on the north side of Arrastra Gulch.[2] This produced a gold ore, of which some 27 tons were treated in arrastres, yielding $150 a ton. The first shipment of ore from the district is said to have been from this mine. In 1872 troops were sent into the region to keep out the miners, as their presence constituted a violation of the treaty of 1868, by which the Utes were secured in sole possession. In the same year a commission was appointed by Congress to negotiate a new treaty with the Indians to reduce the extent of their reservation. The Little Giant Company was organized in Chicago in 1872, and in 1873 the arrastres were replaced by an amalgamating mill equipped with a Dodge crusher, a ball pulverizer, and five stamps. Power was furnished by a 12-horsepower engine. The mill was built 1,000 feet below the mine and the ore was brought down on the first wire-rope tramway built in the region. This year the mine produced about $12,000 out of a total of about $15,000 for the entire region. The pay shoot, however, began to diminish, and after the milling of a few hundred tons of ore mine and mill were abandoned. Several lodes had by this time been opened in the region and some small amounts of rich ore had been taken out, but it was not until 1874 that the main rush to the country began. In September of the previous year a treaty, known as the Brunot treaty, had been drawn up with the Utes, whereby the San Juan Mountains were thrown open to settlement. The ratification of this treaty by the Senate in April, 1874, was followed by a sudden influx of miners, chiefly from the northern camps of Colorado, but including also a few from the south, and some even from the far West. It is estimated that about 2,000 men came into the district during the summer of 1874, and Endlich[1] reports that more than this number of lodes were then staked out.[2] At that time La Plata, Hinsdale, and Rio Grande were the only counties into which the former reservation had been divided. The chief settlement and the county seat of La Plata County was Howardsville; but in the autumn of 1874 the county seat was moved to Silverton, then a growing town of some dozen houses, admirably situated in Bakers Park. The nearest post-office at this time was Del Norte, about 125 miles distant. In 1876 San Juan County was formed from a portion of La Plata County, with Silverton as the county seat. At this time the town is said to have had a population of about 500 voters. Ouray, San Miguel, and Dolores counties were subsequently formed by legislative enactment from the territory originally included in La Plata County.

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[1] Accounts differ as to the Christian name of this pioneer. Thus Bancroft (History of Nevada, Colorado, and Wyoming, San Francisco, 1890, p. 495) refers to him as *John* Baker; T. A. Rickard, in his paper on The Development of Colorado's Mining Industry (Trans. Am. Inst. Min. Eng., Vol. XXVI, 1896), gives his name as *Jim* Baker; while Frank Hall, in his History of Colorado, makes him *Charles* Baker.

[2] According to Rickard, opened by Miles T. Johnson in 1871.

In 1874 real mining began, principally on Hazelton Mountain, and several hundred tons of gray copper and galena ore were taken out from the Aspen, Prospector, Susquehanna, and neighboring claims during this and the immediately succeeding years. This ore was treated chiefly in Greene & Co's. smelter, which was erected just north of Silverton in 1874, but which was not successfully blown in until the following year. The machinery was brought in on burros from Colorado Springs, then the terminus of the Denver and Rio Grande Railroad. The product of the entire quadrangle for 1875 was about $35,000, and an estimate made in 1877 places the total product from the beginning of mining to the close of 1876 at a little over $1,000,000. The Greene smelter was in intermittent operation until 1879, and was the first successful water-jacket furnace in the State. Its daily capacity was about 12 tons, and it is said to have smelted nearly $400,000 worth of silver-lead bullion. The bullion was shipped by pack train and wagon to Pueblo. The cost of transporting it to the railway terminus was $60 per ton in 1876, $56 per ton in 1877, and $40 per ton in 1878. The average price for treatment was not far from $100 per ton. During the seventies the chief route into the Animas mining district was by the trail from Del Norte on the Rio

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[1] U. S. Geol. and Geog. Surv. Terr., Report for 1876, pp. 120-121.

[2] According to Bancroft, "more than 1,000 lodes claimed." Loc. cit., p. 501.

Grande, by way of Antelope Park and Cunningham Gulch. Over this route the first ore sold from the Pride of the West mine, in Cunningham Gulch, was taken out in 1874. It was not until 1879 that the wagon road from Antelope Park was completed by way of Stony Gulch, and ore could be hauled out to Del Norte by teams at $30 a ton.

The founding of Lake City, about the year 1875, and the establishment there by Crooke & Co. of a smelting plant, afforded a market for the ores of the northeastern portion of the quadrangle. The first ore shipped out from this part of the district was from the Mountain Queen mine, at the head of California Gulch, in 1877. It amounted to 370 tons, and contained 64 per cent of lead and 30 ounces of silver per ton. It was carried by pack animals to the end of the road at Rose's cabin, at a cost of $3 per ton. Crooke & Co., of Lake City, and Mather & Geist, of Pueblo, both had ore-buying agencies in Silverton in 1879. During this year about 500 tons of ore, worth about $60,000, were sent to the Lake City smelter, and about 185 tons went to Pueblo. The value of the latter was probably about $25,000.

In 1879 a road was completed from Silverton up Cement Creek to the head of Poughkeepsie Gulch, where prospecting and mining was going on with great activity on the Old Lout, Alabama, Poughkeepsie, Red Roger, Saxon, Alaska, Bonanza, and other claims. Chlorination and lixiviation works were erected at Gladstone about this time, to treat these ores by the Augustin process. Their capacity was about 6 tons per day.

During the seventies the eastern and northeastern portions of the quadrangle were actively prospected, and nearly every lode which has subsequently proved valuable was then located. In some cases paying ore was taken out in large quantities, as from the North Star mine on Sultan Mountain and others already referred to. But this activity was in great part feverish and unwholesome. The success of a few encouraged extravagance in the incompetent, and opened a rich field to unscrupulous and dishonest promoters. Smelting plants and mills were erected before the presence of ore was ascertained. Reduction processes were installed without any pains having been taken to ascertain their applicability to the particular ores to be treated. Thus in 1876 Animas Forks was a lively town of some 30 houses and 2 mills, and in 1883 boasted of a population of 450. But there was never any real justification for its existence. Built upon hopes never realized, its decline was almost as rapid as its rise, and the town is now ruined and desolate. Its principal mill was put up in 1875 or 1876 to treat ore from the Red Cloud mine, but was never successful. The Eclipse smelter, erected by James Cherry as late as 1880, at the mouth of Grouse Gulch, ostensibly to run on lead ores from the Mountain Queen and other claims, was also a costly failure. The Bonanza tunnel, a mile and a half west of the town, was run 1,000 feet at the extravagant cost of $300,000 or $400,000, and then abandoned. Around Mineral Point probably $2,000,000 or $3,000,000 were squandered in mining operations which resulted in no permanent improvements or actual development. Numerous similar cases might be cited from this region, many of them unfortunately of much more recent date. Capital thus invested serves only to build monuments of failure, folly, and dishonesty, which may operate to delay for years such development and improvement as the mineral resources of a district really warrant.

In 1881 the remarkable deposits between Red Mountain and Ironton were discovered, and in 1882 and 1883 prospectors swarmed into this new field. The Yankee Girl ore body was struck in 1882, and, with the Guston, shipped large quantities of high-grade silver ore for over fourteen years. These two mines alone have probably produced at least $6,000,000 or $7,000,000, but a very large amount of capital has been vainly expended in attempts to find other ore bodies in the vicinity equally large and rich. Nowhere else in the quadrangle has mining been carried on so extensively. In 1888 the railroad was extended from Silverton to Ironton, greatly facilitating the marketing of the ore. Red Mountain and Ironton were formerly thriving mining towns of 400 or 500 inhabitants, and the activity steadily increased almost up to 1893, when the fall in the value of silver and the exhaustion of the phenomenally rich portions of the ore bodies caused the boom to collapse. The Yankee Girl and Guston mines continued working until 1896, but the low price of silver and the increased expense involved in deep workings and in handling the troublesome corrosive waters of these mines, together with the lower grade of the ores in depth, finally compelled them too to shut down. From that time to the present Red Mountain and Ironton have remained practically dead camps.

Previous to the advent of the railroad in Silverton, ores running less than $100 per ton could seldom be handled with profit, but with the completion of the Silverton branch of the Denver and Rio Grande narrow-gauge railroad in July, 1882, the rate of transportation on low-grade ores was much reduced, and many mines hitherto unavailable became productive. Freight charges, at first $16 per ton to Denver or Pueblo, were soon dropped to $12, at which high figure they stood for some time. Over 6,000 tons of ore were shipped from Silverton during the first six months after the advent of the railroad. The Greene smelter had some years previously (about 1880) come into the possession of the New York and San Juan Smelting Company, which in 1881 moved the Silverton plant to Durango and in 1882 started the present smelter in that town. In September, 1887, the name was changed to the Durango Smelting Company, which operated until April 1, 1888. From that date until May 1, 1895, business was carried on under the name of the San Juan Smelting and Mining Company, a corporation organized through the consolidation of the Durango Smelting Company of Durango, and the Hazelton Mountain Mining Company, of Silverton, owners of the Aspen group of mines. The Martha Rose smelter, with a capacity of about 20 tons, began operations in Silverton in 1882, but after smelting about 11 tons of bullion shut down and was never successfully reopened.

The year 1883 was a busy one in Silverton, and the population of the town rose to over 1,500 inhabitants. Sampling works had previously been erected by E. T. Sweet and T. B. Comstock & Co. Late in the season a third plant was opened by Stoiber Brothers. The North Star on Sultan, the Belcher, Aspen, Gray Eagle, North Star on Solomon, the Green Mountain, as well as the Red Mountain mines, were all actively producing, while great strikes were announced in the Ben Franklin and Sampson mines. The Silver Lake mine also came into prominence and shipped that year 72 tons of ore to Sweet's sampling works.

It was not until about 1890 that any real attempt was made to concentrate low-grade ores. The credit of thus initiating a procedure upon which largely depends the future of the whole district must be divided between J. H. Terry, of the Sunnyside mine, and E. G. Stoiber, of the Silver Lake mine. Both men have been successful, and Mr. Stoiber in particular has shown how low-grade veins may be worked successfully on a large scale with a modern plant. About this time the North Star mine, on Sultan Mountain, put up the present mill, run by water power, and in 1894 Thomas Walsh and others erected the matte smelter just west of Silverton. Walsh treated by the Austin process the lower-grade Guston ore, and bought siliceous ores wherever he could obtain them. This smelter ran pretty steadily for three years and finally shut down. Its capacity was about 100 tons of ore a day for ten months in the year. In all, about 100,000 tons of low-grade siliceous and pyritiferous ores were treated. There was no further attempt made to smelt ores in Silverton until the construction in 1900 of the pyritic smelter, near the mouth of Cement Creek. The smelter at Durango, which was leased in 1895 by the Omaha and Grant Company, and which on May 1, 1899, became the property of the American Smelting and Refining Company, has continued to handle the bulk of the ore and concentrates from the Silverton region.

With a few notable exceptions the mines of the Silverton quadrangle produce ores in which silver and lead are the predominant metals. Naturally the rapid decline in the value of silver in 1892 and succeeding years resulted in the closing of many mines hitherto productive, and in a general decrease of mining activity. At the present time, however, there are signs of a favorable reaction and a marked increase of activity. The success of Messrs. Stoiber and Terry in handling low-grade ores has demonstrated that when wasteful and inadequate methods are replaced by modern appliances and shrewd management, mines carrying abundant low-grade ore may be made profitable, even with the present low price of silver. Probably, as in the past, periods of depression will sometimes retard mining improvements. Yet it is clear that the resources of the district have been far too often superficially, ignorantly, or wastefully exploited. Although examples of extravagance are still not hard to find, there is now a more general realization of the distinction between such wasteful expenditure and the legitimate and often large outlay that makes possible the economical working of known low-grade ore bodies. It is very probable that the future will see a great and permanent increase in the productive development of such large and persistent ore bodies of low average grade. The decline in the price of silver, and also in that of lead and copper, which are important constituents of most of the ores, has greatly reduced the margin of profit and rendered economical working imperative, as is illustrated in the following table:

Table showing the average annual prices of silver, lead, and copper, from 1880 to 1899.

Year.	Silver, per fine ounce.	Lead, per 100 pounds.	Copper. per pound.[a]	Year.	Silver, per fine ounce.	Lead, per 100 pounds.	Copper, per pound.[a]
1880	$1.145	$5.03	$0.216	1890	$1.050	$4.35	$0.156
1881	1.138	4.81	.188	1891	.988	4.33	.128
1882	1.136	4.91	.185	1892	.874	4.07	.115
1883	1.110	4.32	.159	1893	.779	4.10	.108
1884	1.113	3.74	.139	1894	.634	3.28	.094
1885	1.065	3.94	.110	1895	.658	3.24	.107
1886	.995	4.61	.110	1896	.674	2.97	.109
1887	.978	4.50	.113	1897	.603	3.60	.112
1888	.940	4.41	.168	1898	.588	3.75	.119
1889	.936	3.81	.134	1899	.601	4.44	.177

[a] Lake Superior ingot.

The prices of silver are taken from the annual reports of the Director of the Mint. The lead and copper values are compiled from tables showing monthly prices and monthly range in the reports on mineral resources issued as parts of the annual reports of the Geological Survey.

Although the first mine to be worked in the district was a gold producer, yet it is an interesting fact that for many years prospecting was practically restricted to a search for silver and lead ores. It was apparently owing to this adherence to an established routine that the Una and Gertrude claims in Imogene Basin, worked twenty years ago for silver and lead, were subsequently abandoned, with no knowledge of the remarkable gold ore which lay close alongside the argentiferous streak, and which was thrown out as waste. Masses of this rich ore were discovered by Thomas F. Walsh on the Camp Bird claim, and subsequently on the dump of the old workings of the Una and Gertrude, and he purchased the latter in 1896 for $10,000. It is to-day one of the greatest producing mines in the quadrangle, and certainly excels all others in the average richness and regularity of its ore bodies.

Placer mining has never been extensively practiced within the Silverton quadrangle. In former years a little washing was done on the east side of California Mountain, in Picayune Gulch, and in Arrastra Gulch, but there are no extensive deposits of auriferous gravels in the district, and the total output from placer mining is probably insignificant.

PRODUCTION.

Accurate figures from which the total production of the Silverton quadrangle might be computed are not available. The area comprises portions of several counties, and has shipped ore to various smelters. An attempt to ascertain and combine the products of the individual mines within the quadrangle has been only partially successful. In the case of some abandoned mines no records can be found, and in two instances requests to the owners of active mines for confidential statements of total output have met with no satisfactory response; but by combining actual figures with individual estimates it appears that the total production of the Silverton quadrangle from the beginning of mining activity to the close of 1900 has been at least $35,000,000. The greater part of this has undoubtedly been in silver, but during recent years, largely owing to the activity of the Camp Bird, Tomboy, and Gold King mines, and to the lower price of silver, the value of the gold output has predominated.

CLIMATE.

The climate of the Silverton quadrangle is, in general, somewhat rigorous. Meteorological records are lacking for this elevated region, and no accurate data can be given in regard to temperature and precipitation. The winters are long, the snowfall is heavy, and the temperature sometimes falls to 20° to 30° below zero. The first heavy snow usually arrives late in October, but heavy falls are not unknown in September. This early storm may be followed by fine weather, lasting well into December. In midwinter snowshoes afford the only means of communication over most of the higher roads and trails. Snowslides are frequent and dangerous, and a winter seldom passes without loss of life and property from this cause. It is often late in June before the snow has disappeared from the higher trails; and on northern slopes, sheltered from the sun, patches frequently linger until long after midsummer. The period extending from the beginning of July to the middle of August is referred to by the inhabitants as the "rainy season." During this period in normal years showers are of almost daily occurrence, usually coming up early in the afternoon and lasting for an hour or more. It is during this season that the wild flowers in the upland basins, notably many species of gentians and a magnificent lilac-colored columbine (*Aquilegia cærulea*) attain the height of their luxuriant beauty. The temperature at this time is changeable. The transformation from balmy air, genial sunshine, and humming insects to cold winds, dark clouds, and chilling rains is by no means uncommon, and may take place in an hour. The month of September is usually delightful. The rainy season has passed, and toward the end of this month the aspens assume their yellow and orange autumnal coloring, enlivening and softening for a brief period a landscape in which bleak grandeur is the rather too dominant element.

VEGETATION.

Most of the slopes, up to a timber line varying from 11,000 to 11,500 feet, are covered with firs, spruces, and aspens, the last flourishing particularly on the southern exposures and on the talus slopes. Although unsuitable for good sawn lumber, the firs and spruces furnish round timber of sufficient size and strength for ordinary timbering in the mines. The basins, being mostly above 11,500 feet, are treeless, but are covered in summer with a luxuriant growth of grass and flowers.

TOPOGRAPHY.

For more complete accounts of the topography of the region the reader is referred to the general geological text of the forthcoming Silverton folio. The present sketch is confined to such considerations of topographic form as are necessary to enable the reader to fully understand the modes of occurrence of the ore bodies and the conditions governing their exploitation.

The lowest point within the quadrangle is found on its northern edge in the canyon of the Uncompahgre, where the contours (Pl. IV) show an elevation of somewhat over 8,100 feet. The highest point is Handies Peak, on the extreme eastern edge of the area, with an altitude of 14,008 feet. Between these extremes the region exhibits such abrupt and frequent variations in relief as to constitute a topography of the most rugged character. This assemblage of sharp peaks, jagged ridges, steep-walled basins, and deep canyons is the result of vigorous erosion, acting for the most part on nearly horizontal volcanic rocks. The present drainage system is apparently irregular or autogenous—that is, uncontrolled to any recognizable degree by regular structure in the rocks—and was undoubtedly established in essentially its present form prior to the epoch of glaciation. Of the character of the initial land surface, upon which the present streams began their work, we know very little. We may assume, with some degree of probability, that it was the surface of a broad, dome-like elevation extending beyond the bounds of the quadrangle, which, after its original structural doming, had been reduced by erosion to an irregular plateau near the end of the Cretaceous. This was buried to a depth of several

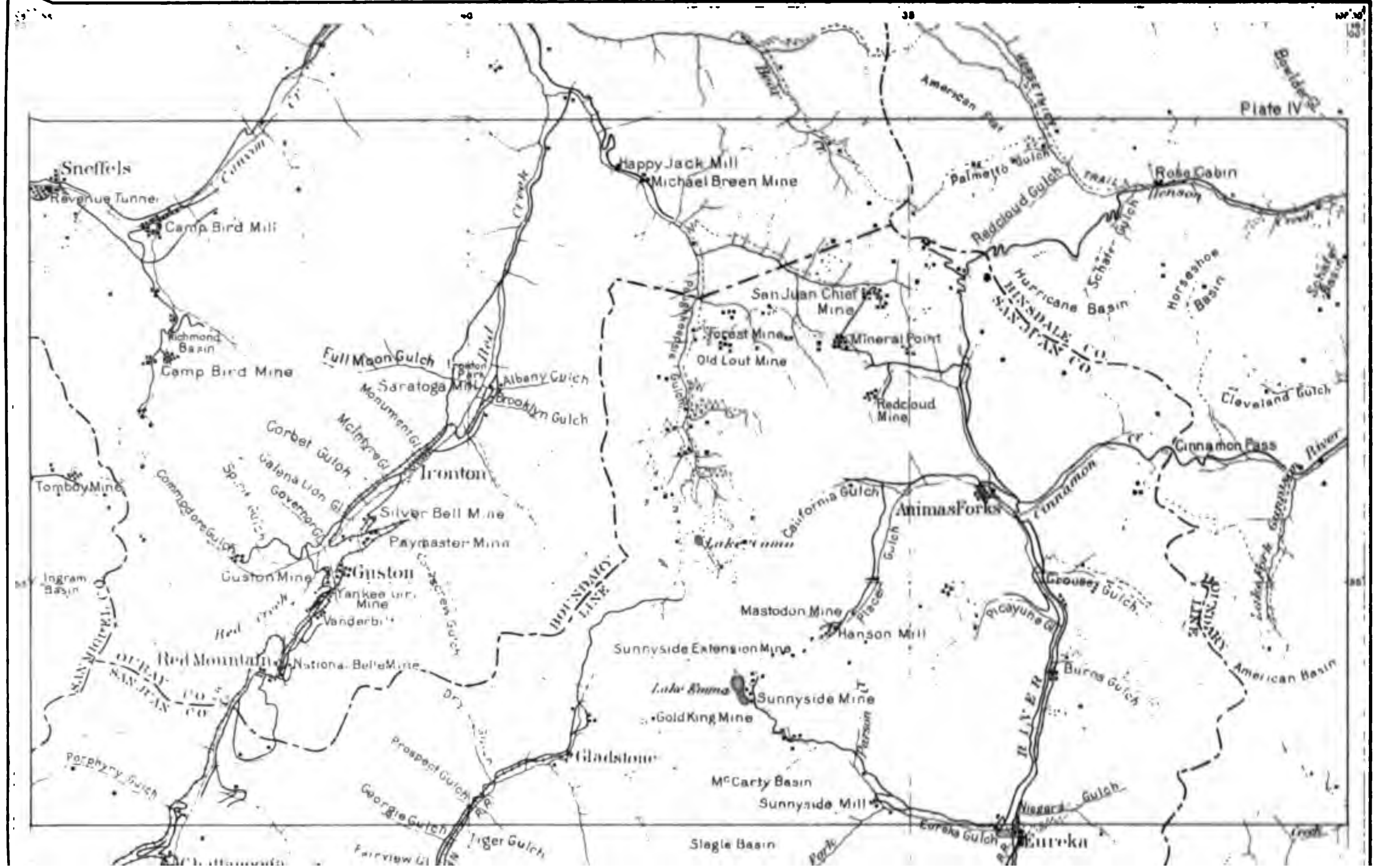
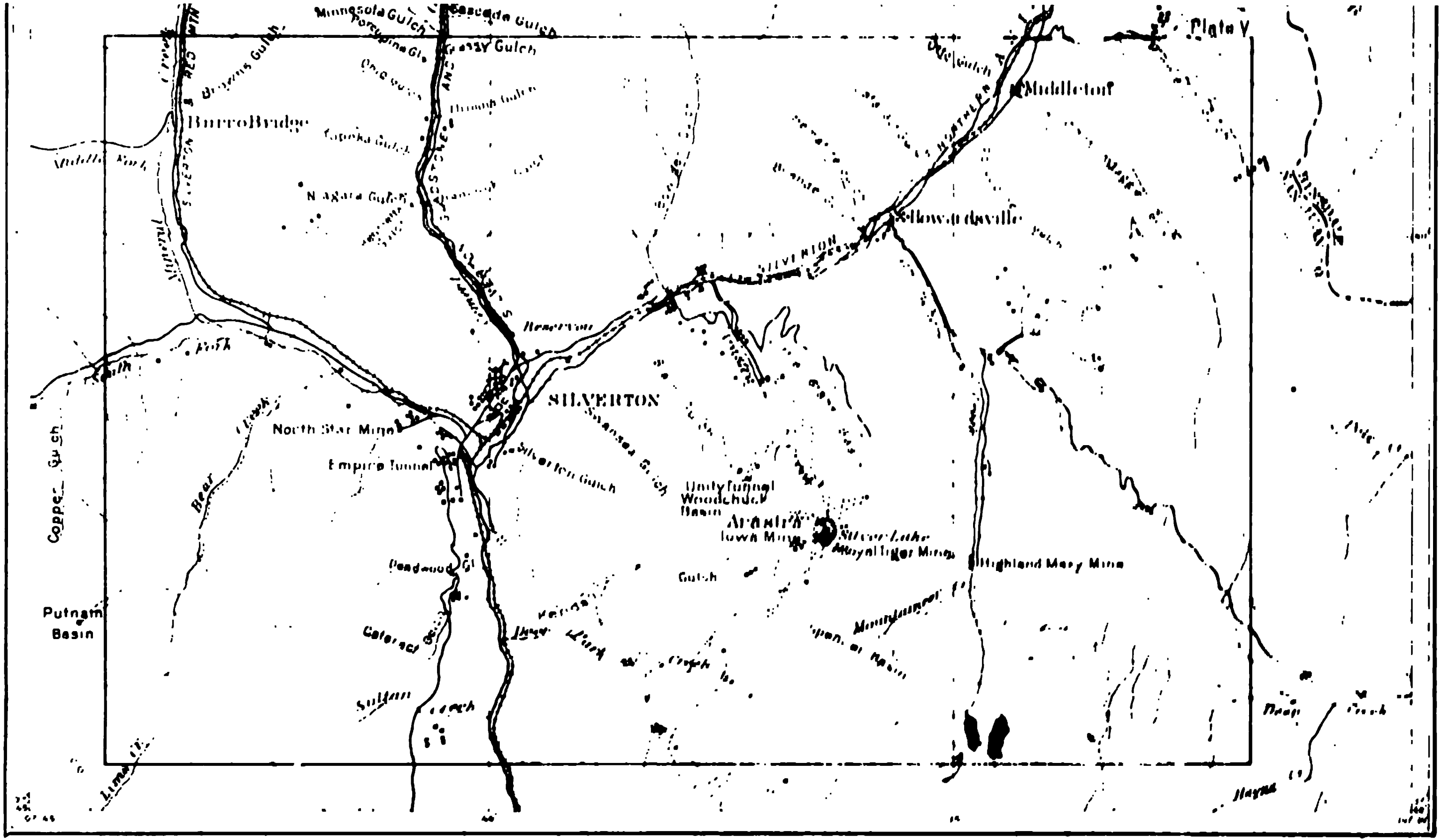


Plate IV
Sneffels
Revenue Tunnel
Camp Bird Mill
Canyon Cr.
Richmond Basin
Camp Bird Mine
Tomboy Mine
Ingram Basin
Commodore Gulch
Spirit Gulch
Governor Gl.
Galena Lion Gl.
Corbet Gulch
McIntyre Gl.
Monument Gl.
Full Moon Gulch
Saratoga Mill
Albany Gulch
Brooklyn Gulch
Red Creek
Ironton
Silver Bell Mine
Paymaster Mine
Corkscrew Gulch
Guston
Guston Mine
Yankee Girl Mine
Vanderbilt
Red Creek
Red Mountain
National Belle Mine
SAN MIGUEL CO.
OURAY CO.
SAN JUAN CO.
Porphyry Gulch
Georgia Gulch
Prospect Gulch
Dry Gulch
Fairview Gl.
Tiger Gulch
Gladstone
BOUNDARY LINE
Happy Jack Mill
Michael Breen Mine
Poughkeepsie Gulch
San Juan Chief Mine
Forest Mine
Old Lout Mine
Mineral Point
Redcloud Mine
Lake Como
California Gulch
Animas Forks
Placer Gulch
Mastodon Mine
Hanson Mill
Sunnyside Extension Mine
Lake Emma
Sunnyside Mine
Gold King Mine
McCarty Basin
Sunnyside Mill
Slagle Basin
Eureka Gulch
Eureka
Niagara Gulch
RIVER
Burns Gulch
Picayune Gl.
Grouse Gulch
Cinnamon
Cinnamon Pass
American Flat
Palmetto Gulch
Redcloud Gulch
Bear Cr.
Rose Cabin
Henson Creek
Schafer Gulch
Hurricane Basin
HINSDALE CO.
SAN JUAN CO.
Horseshoe Basin
Schafer Basin
Cleveland Gulch
Lake Fork Gunnison River
BOUNDARY LINE
American Basin
Boulder Gl.



OUTLINE MAP OF THE SILVERTON QUADRANGLE, COLORADO
Showing areas covered by Plates IV and V
Scale

thousand feet by volcanic accumulations in Tertiary times, and has been complicated by faulting and minor oscillations. No recognized trace of this surface remains. The topography, as we know it to-day, is the product of stream erosion, modified by glaciation and the powerful disintegrating action of frost at these high altitudes. It is essential in all discussions relative to the lodes to keep in mind the fact that the entire topography is due to erosion, and that the highest peaks are but residuals which owe their relative height to the resistant materials of which they are composed, or to their distance from the main streams, but in no sense to direct and local elevations.

With the exception of Bakers Park, Ironton Park, and perhaps the gently sloping bit of upland at the head of Henson Creek, commonly known as American Flats, no considerable areas of approximately level land occur within the quadrangle. The mountains rise in steep slopes, or in inaccessible cliffs, often from 3,000 to 4,000 feet in height from the bottoms of the main canyons. The smaller streams descend these precipitous declivities in successions of waterfalls, or occupy small ravines or gulches of high gradient, such as Niagara Gulch near Eureka, Porcupine Gulch, or the gulches northwest of Howardsville. The larger tributaries have frequently excavated long canyons of moderate gradient, such as Cunningham and Poughkeepsie gulches, but in these there is nearly always a point near the headwaters where a moderate gradient is succeeded by a much steeper one. Most of the streams, large and small, head in cirques, or "basins" as they are locally termed, which often contain one or more lakelets. These basins form a very characteristic feature of the topography, and their general shape and character are admirably illustrated by the amphitheaters just north of Sultan and Bear peaks (Pl. V).

The rock floors of these basins, often of somewhat hummocky character, generally slope upward on three sides and pass beneath the talus or "slide rock," with which they are always partly filled. Above the talus and inclosing the basin on three sides are usually more or less precipitous cliffs, from which have fallen the fragments making up the talus at their base. As may be seen from the maps, these cliffs are merely the sides of narrow ridges, surmounted by peaks and intersected by cols or saddles which separate adjacent basins. The talus frequently extends up to a saddle, and it is then possible to pass from one basin to another over the divide. At their lower ends the basins are usually terminated by a precipitous descent to a gulch or to a second basin at the lower level. This relation is well shown in the case of Silver Lake Basin and Arrastra Gulch. When the connecting gulch is very short and steep, as Niagara Gulch, the basins have the form of hanging valleys. The talus that always lies against the cliffs and slopes rimming the basins represents in some cases the gradual accumulation of comparatively small fragments, such as may frequently be heard rattling down the cliffs during the spring and summer. But in many instances it is plainly the result of one or more rock slides of some magnitude, by which large masses of the cliff have fallen and slid out onto the floor of the basin.

The lakelets lying in these basins or amphitheaters are usually rock-rimmed and often of considerable depth. The existence of the lakes depends merely upon the characteristic form of the main basins or cirques in which they lie. This form is immediately due to the eroding action of local glaciers which once occupied the basins. The outlet of Silver Lake flows over a sheet of hard, massive andesite, whose surface has been rounded and scored by the ice. The lake basin itself has been excavated, however, in softer, more readily erodible volcanic breccias. Ordinary erosion by running water would have been powerless to excavate such a basin below the level of its present outlet. Ice is the only eroding agent that could produce such a result.

The evolution of the topography has undoubtedly been influenced to some extent by the fissures and veins that are so abundant in this region. But it is difficult or impossible to reduce their effect to the form of a simple and general statement. Mineralized fissures are frequently lines of comparatively easy oxidation, rapid decomposition, and ready erosion. Thus very many of the lodes determine the position of the cols or saddles in the ridges, and can be distinguished from a distance by the yellowish color of their surface detritus. Yet this is by no means universally true. It often happens that in the present stage of erosion the croppings of a vein traverse an even slope or cross the summit of a high peak. As an example of the last may be cited the important Titusville vein where it crosses Kendall Mountain. It is plain that in some cases the fact that erosion has resulted in cliffs rather than steep slopes is due to the presence of nearly vertical fissures. A system of such fissures running nearly northeast and southwest is responsible for the cliffs which separate Silver Lake Basin from Arrastra Gulch.

In this elevated region the disintegrating action of frost and the active erosion far outstrip the chemical processes of decay which in mild and moist climates are efficient in reducing the rocks to soil. As a consequence the high peaks and ridges are usually composed of bare rock, while their lower slopes are largely made up of talus or "slide rock," as it is locally called. This talus has concealed in a most effectual manner much of the rock once scoured clean by the ice, and has restricted most of the prospecting to the high peaks and ridges where the veins are exposed.

In the vicinity of Red Mountain and Ironton much of the topography has a peculiar hummocky character, which is the result of landslide action. This feature is particularly striking on the northern and western flanks of Red Mountain. Several of the Red Mountain mines, such as the Yankee Girl, Genesee-Vanderbilt, Guston, Silver *Bell, Paymaster*, and others, are in this landslide area. But the ore bodies of these mines appear to be in place. Apparently the landslide action is rather superficial, and the siliceous outcrops of the larger ore bodies have remained stationary, while the fractured and mineralized rock around them have slid in considerable masses down the slope. Obviously such sliding renders superficial prospecting very unsatisfactory. It is quite possible that some ore bodies have been covered by landslide material and entirely concealed. For further account and discussion of landslide areas in this and other portions of the quadrangle the reader is referred to the heading "Landslides" (p. 37), in the outline of geology given by Mr. Whitman Cross.

OUTLINE OF GEOLOGY.

By Whitman Cross.

SAN JUAN VOLCANIC AREA.

The complex of volcanic rocks within which the Silverton quadrangle is situated is one of the most extensive in the Rocky Mountains. It consists of a series, several thousand feet in thickness, of tuffs, agglomerates, and lava flows. The more or less distinctly horizontal surface volcanics have been penetrated by later stocks of various rocks, ranging in composition from gabbro almost to granite, and by numerous small dikes of a considerable variety of rocks. The eruptions began with the Tertiary and continued during the greater part of that era.

The area covered at the present time by these volcanic rocks is in general well shown by the Hayden map of Colorada. The main peaks of the San Juan Mountains are situated in the western center of the area. From this point the volcanic series extends northward across the Gunnison River to the West Elk Mountains, eastward to the San Luis Valley, and southeasterly a broad arm passes a considerable distance into New Mexico.

The former extent of the San Juan volcanics was very much greater than at present. There is evidence of enormous erosion, which was greatest along the western and southern sides, and it appears that very possibly the high mountains of the Telluride and Silverton quadrangles are near what was the center of the volcanic area at its maximum. Certainly the former border of the volcanic pile must have been located many miles farther west and south than at present.

The Hayden map of this region is only of general value. There is great complexity within the area of surface lavas and agglomerates, and the map shows in part quite incorrectly the relations of sedimentary and other formations on the borders of the volcanic rocks. The resurvey of this extensive tract has not progressed sufficiently to permit the preparation of a satisfactory outline of San Juan geology. In the Telluride folio, however, an attempt has been made to present the results of the more recent work in their general bearing.

From the western front of the San Juan Mountains one looks down upon a great plateau level which reaches for hundreds of miles westward. This level is nearly 2,000 feet below the base of the volcanic series. The isolated mountains which modify this plateau country in the zone bordering the San Juan Mountains are in all cases due to igneous intrusions which have in a measure protected the softer sedimentary beds from erosion.

The removal of the western part of the original volcanic complex has revealed a complicated structure in the underlying older formations, showing that the general center of volcanic activity has also been the site of several great disturbances in earlier geologic times. About a center not yet very well located, because covered by the remaining volcanics, the sedimentary formations of Paleozoic and Mesozoic times have been upturned and eroded at several periods. This structure is well shown in the zone bordering the present western projection of the San Juan Mountains and in the canyons cutting through the volcanics.

The first quadrangle in this area to be resurveyed was the Telluride, lying directly west of the Silverton. The main western front of the San Juan Mountains traverses this quadrangle from north to south in an irregular line, and the fine exposures of the high peaks and deep canyons permit a clear understanding of the principal elements in the mass of the volcanic series, in this portion of the area at least. The sedimentary formations below are also very clearly shown in the Telluride quadrangle. The somewhat detailed text of the Telluride folio[1] must be referred to for much general information which is applicable to certain parts of the Silverton quadrangle.

GEOLOGY OF THE SILVERTON QUADRANGLE.

Location with regard to the volcanic area.—The Silverton quadrangle lies almost wholly within the volcanic area, but two streams, belonging to the drainage of the Colorado River, have cut through the volcanics and disclosed the underlying formations.

On the north the Uncompahgre River with its tributaries, Canyon Creek and Red Creek, reveal the Algonkian quartzites and the Paleozoic and Mesozoic formations underneath the volcanics. The lower members of the section appear in the Silverton quadrangle. From the south the Animas River has penetrated far into the quadrangle, and below Silverton it flows in a canyon excavated below the volcanics. This stream has cut a deep gorge through the Needle Mountains, which rise immediately south of the Silverton quadrangle to elevations of over 14,000 feet. These mountains are composed very largely of Archean and Algonkian rocks. On the west no stream has eaten back into the area of this quadrangle with the exception of the two short tributaries of the San Miguel heading in Ingram and Savage basins. On the eastern border the Lake Fork of the Gunnison River has exposed a mass of granite which is entirely surrounded by volcanics, but as its boundaries are at least in part fault lines, it is possible that dislocations on these planes have produced this outcrop by local upthrust. The structures observable in the formations beneath the volcanics show the Silverton quadrangle to be near the center of an area of repeated orogenic disturbance in Paleozoic and Mesozoic times. Some of the igneous phenomena seem also to center here, but it is as yet premature to conclude that the principal center of the entire volcanic activity was in this vicinity. There may have been several centers of eruption whose products combined to form the great complex known.

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[1] Geologic Atlas U. S., folio 57, 1899.

All of the principal members of the volcanic series thus far identified are exhibited in the Silverton quadrangle. There are also a number of intrusive rocks, most of them having been previously observed in the Telluride quadrangle. The principal elements of the igneous complex will now be briefly described.

San Juan formation.—The earliest volcanic formation of this series revealed to the present time has been termed the San Juan formation. It is a more or less perfectly stratified series of tuffs and agglomerates of andesitic rocks, no lava flows having been observed within it. The character of the San Juan tuff and agglomerate in its greatest known development is very clearly exhibited on either side of Canyon Creek. It reaches there a thickness of fully 2,500 feet (Pl. IV). In many parts the San Juan seems to be a water-laid deposit, so fine is the stratification. The agglomerates are more or less chaotic, but exhibit distinct stratification when seen in large exposures. These tuffs and agglomerates are also exposed in typical development in the mountain group southwest of Silverton, of which Sultan Mountain and the Grand Turk are the most notable summits. The thickness is here, however, but 1,500 feet. On the east side of the Animas the San Juan tuffs are exposed in very irregular thickness on the slope of gneisses and granites descending from the Needle Mountains. Apparently, erosion was here extremely active in the period succeeding the San Juan fragmental eruptions.

On the eastern side of the Uncompahgre River the floor upon which the San Juan rests and also its upper surface dip rather abruptly southward, bringing the succeeding formation abruptly down to the level of the river, and the San Juan does not reappear in the canyon-like valleys of the streams in the eastern portion of the quadrangle. It is plain that in the entire valley of the Animas from Silverton to Animas Forks the volcanics rest upon a surface much lower than that which constitutes their base in Sultan Mountain. Whether this fact is due to an original depression in this area or to subsequent sinking has not yet been determined.

Silverton series.—The next volcanic series after the San Juan was termed the "Intermediate series" in the Telluride folio. It was very much less developed there than either the San Juan below or the Potosi series above. The relations exhibited by the map (Pl. IV) in Potosi Peak and the mountains south of Canyon Creek are typical of what was observed throughout the Telluride quadrangle. But, as the map clearly shows, this formation increases rapidly in thickness eastward and covers, in fact, much the greater part of the Silverton quadrangle. It will therefore be known in future as the Silverton series, the undesirable term "Intermediate" being discarded. From a thickness of 300 or 400 feet in Potosi Peak the Silverton series increases to 4,000 or 5,000 feet in observed thickness near the center of the quadrangle. This series is a complex of andesitic flows and tuffs alternating with rhyolitic flows, flow-breccia, and tuff. In the Telluride quadrangle, and in most places in the Silverton, its lowest member is a rhyolitic flow or flow-breccia of peculiar character. This is well seen in Potosi Peak, along the crest of the range west of Mineral Creek, and very near the summit of Sultan Mountain.

The relation of the different rocks to one another is very variable in different places. Rhyolite is seldom typical, and its largest masses are reddish flow-breccia—that is to say, lavas of rhyolitic base containing many inclusions of both rhyolite and andesite. Very seldom indeed is the rhyolite free from these inclusions. The andesitic portion of the series consists of augite- and hornblende-andesites, and the relation of massive rock to tuff or agglomerate is extremely irregular. In all the central portion of the quadrangle the Silverton series appears to be principally composed of andesite, either fragmental or in flows. But in the Animas Valley the lowest exposed member of the complex, especially along the eastern side from Cunningham Gulch upward, is a rhyolitic flow-breccia of reddish or almost purplish color, so full of impurities that its character is not easily recognized. It appears either that these rhyolite flows were considerably eroded or that they piled up in quite irregular masses at eruption, for the surface upon which the succeeding andesitic rocks rest is extremely irregular, as will be shown by the final geologic map. The recurrence of rhyolitic material at various horizons within the series may be observed at many points. The Silverton series consists, then, of an irregular alternation of two quite different rocks, erupted doubtless from different centers. They are grouped as one series, because the complex contrasts as a whole so markedly with the products of the San Juan epoch below them, which were purely andesitic and entirely fragmental as far as seen, and with the Potosi series above, which is almost entirely rhyolitic in character.

Potosi series.—The uppermost series recognized in the Telluride quadrangle was termed the Potosi series from its occurrence in maximum development in the peak of that name, situated in the extreme

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northwestern corner of the Silverton quadrangle. This series is distinguished as marking the beginning of an epoch of almost exclusively rhyolitic eruptions. For a time, at least, eruptions of more basic rocks were suspended. In Potosi Peak itself, and, indeed, in the Telluride quadrangle, so far as this series was observed, the floor upon which the earliest Potosi lavas were outpoured was approximately level. But either the great development of the Silverton series to the east or other causes have limited the distribution of the Potosi in this first observed simple relation to the other volcanics. No rhyolites which might be correlated with the Potosi series occur to the east in the Silverton quadrangle until the rugged crest of the continental divide is reached. Here several summits, like Sheep Mountain, show light-colored, fluidal lavas at their summits, but they are not sufficiently like the Potosi rhyolites, as known to the westward, to fully justify at this time a certain correlation between them.

The rhyolitic lavas which occur in the higher summits of the northeastern portion of the quadrangle seem more nearly related to the Potosi type, but further examination in the mountains of the Ouray quadrangle is necessary to show the true relations of these lavas to those of the Potosi series.

Stock eruptions.—At a later period than that of the Potosi rhyolite there were in the western San Juan several eruptions of magmas, differing much in composition, and now seen in the form of rather coarsely crystalline rocks penetrating the whole series of surface volcanics to the summits of the highest mountains.

In the Telluride quadrangle a series of these large stocks were observed, in Mount Sneffels, and Stony Mountain, Ophir Needles, Grizzly Peak, and Mount Wilson, all of whose summits are in these stock rocks. There are also several stocks in the Silverton quadrangle, the largest being that of quartz-monzonite, the massive rock of the mountains immediately southwest of Silverton. This stock has a very irregular outline. It extends from Copper Gulch on the west to the base of Kendall Mountain on the east, and the site of Silverton is eroded out of this mass. The northern boundary is very much concealed by talus slopes. The evidence that this stock cuts directly across both sedimentary and surface volcanics is clearly seen in the exposures of the southern contact, on Sultan Mountain and Bear Peak. Smaller stocks of monzonite occur also in the lower part of Cunningham and Maggie gulches. A more basic rock of gabbroitic character appears at the head of Henson Creek, where it is crossed by the wagon road leading to the divide.

Other intrusive rocks.—The Silverton quadrangle is notable for several masses of a peculiar porphyry. This rock occurs in several small stocks; one of them forms a portion of the summit of Red Mountain, another is on Round Hill, while a third is seen at the head of Fullmoon Gulch. A very completely decomposed mass of what is probably the same rock is seen on the north side of Mill Creek, and still another occurs to the west of Mineral Creek, between Mill Creek and the Middle Fork. This rock is characterized by large crystals of orthoclase which give it a very marked porphyritic structure. A very small occurrence of the same rock is found on the wagon road a short distance south of the Yankee Girl mine, and another in the knob north of the National Belle. Intrusions of rhyolitic, and probably of other rocks, are known in the surface volcanics of the northeastern part of the quadrangle, but their character has not yet been definitely ascertained.

A sheet-like mass of porphyry occurs at the eastern base of Sultan Mountain. It has been intruded in quite regular manner in the shales just above the Ouray limestone. Several other masses of porphyry, more or less distinctly in sheet form, with a few dikes, occur at the forks of Mineral Creek west of Silverton. In this vicinity all rocks are so extremely decomposed and are so extensively covered with glacial and other superficial material that the outline of the bodies is very difficult of determination.

A large body of porphyry of rude laccolithic outline occurs on the north side of Canyon Creek on the north border of the quadrangle. The representation of this mass on the map (Pl. IV) is provisional, for the topographic map of this region was revised after the porphyry mass had been examined. This mass is an intrusion in the Triassic beds and extends for some distance into the Ouray quadrangle. The cliffs of this mass are very notable as seen from the wagon road leading up Canyon Creek. The rock is usually very much decomposed.

Formations underlying the volcanics.—As explained above, the volcanic rocks rest upon the greatly eroded surface of many older formations which have been repeatedly elevated and eroded at this general center, producing a complex domal structure. The oldest formation displayed is the gneiss and schist series, in which the Animas Canyon is eroded for several miles, beginning about one mile below Silverton. The rocks of this section have not yet been examined in detail, but will be studied in connection with the Needle Mountains quadrangle.

Associated with these gneisses and schists in the Needle Mountains is a series of quartzites and slates several thousand feet in thickness. These rocks cross the Animas a few miles south of the Silverton quadrangle line. A similar section is displayed in the picturesque canyon of the Uncompahgre from the north base of Abrams Mountain to Ouray. Here, too, there are some thousands of feet exposed, but neither the top nor bottom of the quartzite series is shown. On the south the earliest Paleozoic beds or the volcanic tuffs cover the quartzites and schists unconformably. On the north the Ouray limestone rests upon their upturned edges. This great

series of old quartzites and slates has been assigned to the Algonkian period, chiefly from their lack of fossils, and because they may be thus plausibly correlated with the Algonkian rocks of the Grand Canyon of the Colorado.

The earliest Paleozoic formation is a quartzite with some sandy shales 100 to 200 feet thick, which is seen on the west side of the Animas from the monzonite contact to Molas Lake, and imperfectly on the east side of the Animas. This quartzite has been traced down the Animas to a point below Rockwood, and is called the Ignacio quartzite from its characteristic development on the bench where the lake of that name is situated. A southerly dip carries this quartzite onto the southern slope of the Needle Mountains, and there a few indistinct fossils have been found which indicate its Cambrian age.

The rather shaly beds, often calcareous, succeeding the quartzite have as yet yielded no fossils. If there are any Silurian strata in this section they are probably represented by these calcareous shales and sandstones.

The next formation recognized is a heavy white limestone about 200 feet in thickness, which is seen resting directly on the Algonkian quartzites just south of Ouray, and has been called from this locality the Ouray limestone. In the Animas region this limestone rests upon the calcareous shales just mentioned. A few Devonian fossils were found in this limestone by F. M. Endlich during the Hayden survey. At the present time a quite characteristic Devonian fauna has been obtained from this limestone at various places.

Following the Ouray limestone there is a stratigraphic break. Some formation of Lower Carboniferous age should appear at this horizon, and some fossil evidence has been obtained to show that at least remnants of that formation may be found on careful search. But the great series of Upper Carboniferous rocks called the Hermosa formation come nearly or quite in contact with the Ouray limestone in many places. This series of alternating limestones, grits, and sandstones is about 2,000 feet thick and forms the imposing scarp facing the Animas Valley on the west side. The same beds form notable cliffs about the town of Ouray. From the limestone members a very characteristic Upper Carboniferous fauna has been obtained.

At Rico the uppermost division of the Carboniferous was found to be characterized by invertebrate fossils of the Permo-Carboniferous. Three hundred feet of strata have been grouped together as the Rico formation. Evidence is not yet sufficient to demonstrate the presence of the Rico strata in the Silverton quadrangle.

Following the Carboniferous comes the well-known series of reddish grits, sandstones, and conglomerates ordinarily known as the Red Beds. This series has been termed the Dolores formation from its occurrence along the Dolores River, and evidence of its Triassic age has been found in the upper part of the formation. These strata are seen in Canyon Creek and in the southwestern corner of the Silverton quadrangle. All the Paleozoic and Mesozoic formations named exhibit a domal structure by their prevailing dips to the north or to the south, away from the center in the Silverton quadrangle. Beyond the borders of this quadrangle the other formations of the Mesozoic appear.

Prevolcanic surface and the Telluride conglomerate.—The Hayden map represents the volcanic complex of the San Juan as resting on a general plane surface eroded across many different formations. Over considerable stretches the base of the volcanics is represented as approximately level. A detailed examination of the Telluride quadrangle showed that the San Juan tuff was in that region everywhere underlain by a conglomerate free from volcanic material but containing pebbles of very hard sedimentary rocks, Mesozoic and Paleozoic, with schists, granites, and Algonkian quartzites, such as may be seen in the Needle Mountains; that is to say, this conglomerate contained in its pebbles the record of an enormous erosion, such as would be required to produce the surface upon which the volcanic formations in general rest.

This conglomerate below the volcanics was first called the San Miguel conglomerate. It is now necessary to replace that name by another, as it has been found that there is a prior use of that term for a Cretaceous formation in Texas. It is therefore proposed to rename this conglomerate below the San Juan tuff the Telluride conglomerate, or formation, on account of its typical exposures and relations, clearly seen about the town of that name and, indeed, throughout the Telluride quadrangle. The Telluride formation varies greatly in thickness; it is almost 1,000 feet thick in Mount Wilson, on the western border of the Telluride quadrangle. It is 700 feet thick in Sheep Mountain, southwest of Trout Lake, and from that point thins gradually eastward to Sultan Mountain in the Silverton quadrangle, where, on the eastern slope, it has an average thickness of about 30 feet. To the east of the Animas this conglomerate is not continuously developed, but is found occupying hollows in the surface of gneisses and schists. The San Juan tuffs resting upon it bury the small prominences separating these hollows, and the Telluride conglomerate is, as a rule, not conspicuous. It is very distinctly seen, however, beneath the San Juan on both sides of Whitehead Creek. The same thinning of the Telluride conglomerate occurs between Telluride and the exposures in Canyon Creek. The conglomerate is very clearly exposed upon the wagon road leading up the north side of Canyon Creek, and is probably continuous along its southern side to the valley of Red Creek, but beyond that to the east is seen only in disconnected exposures. It is thought probable that the same formation occurs beneath the volcanics in the lower country east of the Uncompahgre River in the Ouray quadrangle.

Structure of the pre-Telluride formations.—The domal structure which has been referred to is clearly seen in the Animas Valley from the Grand Turk Mountain southward. The formations here have a southerly or southwesterly dip, which prevails with some undulations to a point below Durango. Westerly dips prevail in general in the Telluride quadrangle, and northerly dips are seen in the Uncompahgre Valley from Ouray downward. A local structure of interest is seen directly east of Sultan Mountain in the Animas Valley, where the Ignacio quartzites, the Ouray limestones, and the lower Hermosa beds dip rather abruptly northward. The original extent of this fold is not now plain, for these beds are cut off sharply by the great quartz-monzonite stocks, beyond which only volcanic rocks are known for a number of miles. An interesting evidence of the structure of the Paleozoic beds is also seen in Ironton Park. The well-known deposits of the Saratoga mine seem quite clearly to be in the horizon of the Ouray limestone, resting upon Algonkian quartzites, as in the Uncompahgre Valley. They have a westerly dip, which carries them quickly below the level of the park, but along the road on the western side a very few feet of grits may locally be found beneath the San Juan tuffs.

These beds of Ironton Park are supposed to represent the known eastern limit of the sedimentary section which must be continuous beneath the volcanics and which reappears at Telluride, in the drainage of the San Miguel River.

Faulting.—Displacements of the volcanic rocks by faulting are numerous, but it is in most cases difficult to ascertain the amount and character of the displacement. It is supposed that many of the faults seen in the eastern part of the quadrangle, especially in or near the valley of the Lake Fork, have a very considerable throw. In other parts of the area dislocation is, as a rule, comparatively slight. An exception to this statement is afforded by the faults bounding the rhyolite body of Porphyry Gulch, near the head of Mineral Creek. Here there appears to be a sunken block of Potosi rhyolite bordered by faults, some of which are very clearly exposed. Minor faults occur particularly in the southern parts of the quadrangle, on either side of the Animas.

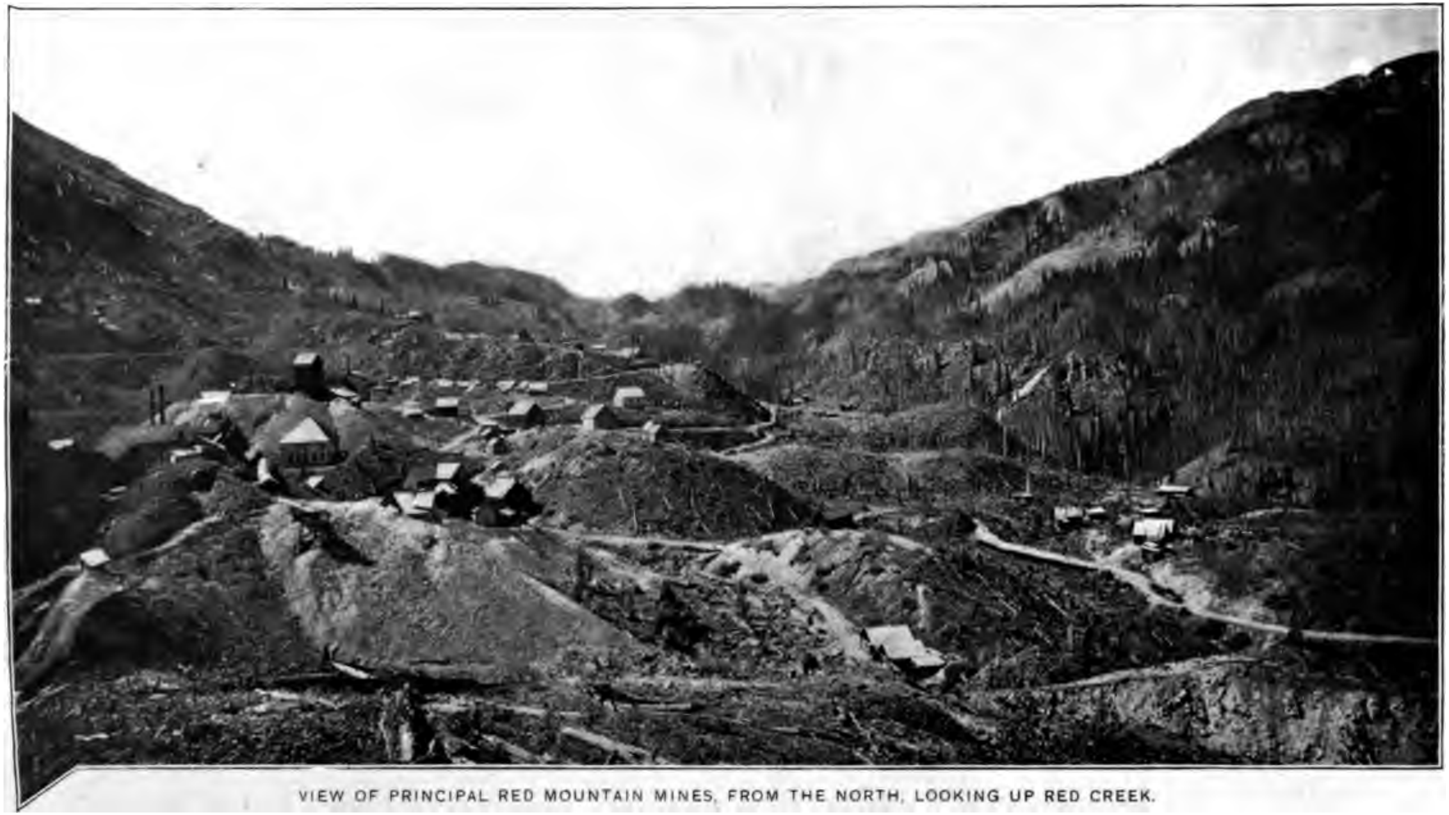
In that region there are faults which seem to be of an earlier date than the volcanic eruptions, but they can be identified as prevolcanic only where they are found to stop at the lower surface of the San Juan. Two such faults are seen in Cunningham Gulch above the Highland Mary mine. Between these faults a block of Ouray limestone has been dropped, and outcrops of that formation occur on each side of the main gulch. These faults do not affect the San Juan tuffs above the Ouray limestone.

Landslides.—The Telluride quadrangle is an area of important landslides, especially on the steep western face of the San Juan, where the Telluride conglomerate rests on soft Cretaceous shales. Two of these slide areas are several square miles in extent and huge blocks have slipped en masse. Minor slides were also noted in several of the gulches of the mountains about Telluride.

The Silverton quadrangle has also been the scene of landslides on an unusually grand scale. The principal area of landslides, shown on Pl. IV, embraces the country on both sides of Red Creek from the lower end of Ironton Park to the head of Mineral Creek, and extends vertically up the adjacent slopes for several hundred feet, or in places 1,000 feet. That landslides have occurred in this region will be evident to all who carefully examine the topographic detail within the areas outlined. This detail is unfortunately too small to admit of expression on the scale of the topographic map. Apparently the movement has been very superficial in comparison with the great slides of the Telluride quadrangle. It has taken place in hundreds of separate small blocks, which are now outlined by trenches or sinks back of the knolls representing the separate masses. When shadows are cast in the right direction the individual knolls of this slide area stand out very clearly. Pl. VI represents a small part of the landslide surface in the vicinity of the Guston mine.

The occurrence of such an area of landslide material is especially interesting in this case because of the fact that the Yankee Girl, Guston, Robinson, Vanderbilt, Paymaster, and other mines are in the heart of the area affected. Since in some cases the ore bodies were traced continuously from the surface downward to depths of over 1,000 feet, it is plain that not all of the surface rock has suffered dislocation, but it is a notable fact that at each one of these mines there is a mound or hill of much-altered rock which stands up as an outcrop in place in the midst of the greatly fractured rock which has slipped downward to an unknown extent through the landslide action. The contrast between a hill of rock in place and the knolls representing landslide blocks surrounding it is very striking in the case of the hill above the Paymaster mine. A critical examination of the mountain side at this point clearly shows that this hill must have been a still more prominent point before the landslide epoch. The great multitude of small slide blocks descending from the higher slope have almost covered Paymaster Hill and have swept down on either side to the level of the main gulch. Whether this landslide material may have entirely concealed mounds of altered rock corresponding to those so prominent at the mines mentioned is an interesting problem to which Mr. Ransome refers.

The evidence of landslide action is chiefly that of the topography, which is entirely irregular and can not have been produced by ordinary erosion. The mounds or knolls can not be regarded as roches moutonnées because of the completely fractured character of the rocks found in them and the fact that many of them are soft tuffs, quite incapable of having resisted moving ice to form a scoriated mound. *It is also notably* the case that rocks of entirely different character



VIEW OF PRINCIPAL RED MOUNTAIN MINES, FROM THE NORTH, LOOKING UP RED CREEK.

view shows the character of landslide topography. The Guston and Robinson mines are on the left; the roof and smokestack of the Yankee Girl shaft house appear in the middle distance; while beyond, on the sky line, is the knoll on which the National Belle is located. Photograph by Whitman Cross.

and different states of preservation are found in juxtaposition, breaking the continuity which is normal where the formations were not thus dislocated.

Landside action of similar character has been very prominent about Rico, in the heart of the Rico Mountains.[1] The result is to produce broad topographic forms of rather gentle outline, modified by many small ridges, knolls, and trenches. Such fractured material is now necessarily in process of further disintegration. Indeed, certain parts of the landslide area adjacent to Ironton Park have been so smoothed out by the ordinary creeping down the slopes of the much-fractured rock that the landslide character is rather obscure. Landslide action on so gigantic a scale is at present attributed to violent earthquake shock. Only some such violent local force seems adequate to explain the enormous slides of the Telluride quadrangle, and the explanation is most plausible in view of the volcanic history of the region.

METHODS OF MINING AND TREATMENT OF ORES.

It is not proposed in this section to go into an exhaustive account of mining methods and metallurgical processes. Such a discussion would be outside the scope of the present report and would necessitate the collection of detailed data of a kind not contemplated in planning geological field work. A brief statement of methods and approximate costs may, however, be of use to readers having no practical knowledge of this district or of the modes of procedure followed in it.

Owing to the exceedingly rugged character of the country, the larger mines, with the exception of those in the Red Mountain district, are almost all worked through adit tunnels. Although involving, as a rule, greater initial expenditure, and, in the case of crosscuts, necessitating much "dead work," such adits have for large mines undoubted advantages in this region over shafts. They obviate the need of pumping, and when, as is commonly the case, there is vertical connection with the surface through old workings, they greatly simplify the problem of ventilation. In a region so elevated as the San Juan an adit tunnel possesses great advantage in that it allows the mine entrance and buildings to be placed as low down as possible, where they can be better sheltered from the winter snow, and where water and timber can be more readily utilized. In several of the larger mines, such as the Silver Lake and Tomboy, shafts are sunk from the adit levels, and hoisting and pumping machinery are installed in underground stations.

The levels are usually, although not uniformly, about 100 feet apart, and the ore is worked out by overhand stoping. It is usually allowed to fall on canvas and roughly sorted from the waste. The stopes are sometimes left open, sufficient timbering being carried up for working purposes. But the more approved practice is to fill in the stopes as the work proceeds, blasting out material from the walls if necessary. In many cases this filling is successfully combined with systematic prospecting of the wall rock on both sides of the vein, often resulting in the discovery of ore which would otherwise have been overlooked. Underhand stoping is, however, practiced in a few mines, as in the Sunnyside, where the proportion of waste which it is necessary to move is small in comparison with the ore.

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[1] Geology of the Rico Mountains, Colorado, by Whitman Cross and Arthur Coe Spencer: Twenty-first Ann. Rept. U. S. Geol. Survey, Pt. II, pp. 129-151.

Machine drills are not generally employed, save in running long crosscuts. The progressive Silver Lake mine began, however, to employ several Siemens and Halske electric drills in its stopes in 1899.

In mines of moderate output the ore is taken directly from the ore chutes and run out in single cars pushed by a man or a boy. In the Silver Lake mine the ore collected from the various drifts and levels is all dumped into ore bins in the main underground station on the adit level, and thence taken out to the mill in a train of cars drawn by a mule. In the Revenue tunnel, which is over 7,400 feet in length, and from which the daily output is some 200 tons of crude shipping ore and an additional amount of milling ore sufficient to furnish 30 to 40 tons of concentrates, the ore is drawn out in a train of cars operated by an electric locomotive. The tunnel is furnished with a double track, but practice has shown that even in an adit of this length a single track is amply able to accommodate a much greater output than that now handled.

Many of the mines being situated above timber line in the high basins, frequently from 2,000 to 4,000 feet above the main roads, the proper location of the mill and the mode of transportation of the ore and concentrates to the nearest railway are problems which must be solved for each mine. Owing to the scanty and intermittent character of the water supply, it is seldom practicable to mill the ores at the altitude of the adit tunnel. An exception must be made in the case of the Silver Lake mine, where water for the mill is obtained by pumping from the adjacent lake. But in most cases the mill is built anywhere from a few hundred to several thousand feet below the mine. The primitive method of packing the ore down on backs of burros to the shipping point or to the mill is in use by nearly all the small mines and prospects. But in well-equipped mines, located above timber line, the wire-rope tramway performs an office which makes it indispensable in the mining development of so rugged a country. These tramways are of various patterns, from the lightly constructed Huson tram, with its small fixed buckets and single rope, to the substantial Bleichert, with large detachable buckets drawn over a fixed rope and supported by well-constructed towers of timber. The Bleichert tramway of the Camp Bird mine in 1899 was running about 45 buckets, each bucket carrying about 700 pounds of ore. One man is able to dispatch 350 buckets a day. This, however, is by no means the full capacity of the tramway, it being restricted in this instance by the limitations of a small Huson tramway which was bringing ore down from upper workings to what is now the main adit. The expense of running these well-constructed gravity tramways is comparatively small, and they are remarkably smooth and efficient in operation.

The ores of the Silverton quadrangle are commercially divisible into shipping ores and milling ores. The former are shipped direct to the smelter as crude ore. They include such high-grade ores as can not be treated economically by simple milling processes and such ores as contain but a small proportion of worthless gangue. The milling ores include such gold ores as can be readily amalgamated or concentrated and those silver-lead ores in which the valuable minerals are associated with considerable quartz or other gangue material. Most large mines produce both grades of ore, while the output of the smaller mines, without mills, is necessarily usually restricted to shipping ore. Exclusive of the ore from the Revenue tunnel, which really comes from the Telluride quadrangle, the bulk of the crude ore at present shipped from the Silverton quadrangle goes to the American Smelting and Refining Company's smelter at Durango. Heavy lead ores preponderate. The treatment charge varies from $2 to $11, the higher rate being for siliceous or "dry" ores. An extra chare of 50 cents per unit (1 per cent of 1 ton) is made for ores running over 10 per cent of zinc.

The treatment of milling ores varies considerably with their character. Formerly many lixiviation plants, usually employing some modification of the original Augustin process, were installed in the region for the treatment of argentiferous ores. This process, involving a chloridizing roasting of the ore and subsequent leaching out of the chloride of silver by the use of strong brine, proved successful in treating the ore of the Polar Star mine, about 95 per cent of the silver being saved. In many cases, however, it was a failure, the ores not being adapted to its employment. At the present time it is no longer used. Mechanical concentration, coupled in some cases with amalgamation, has entirely replaced the various chemical processes, and the concentrates thus obtained are shipped to the smelters.

The silver-lead ores, carrying usually some gold and copper, are crushed by rolls or stamps and, after proper sizing in revolving screens, are concentrated by means of jigs and shaking tables. For this purpose the Wilfley table is most in use, although Woodbury, Bartlett, and Cammett tables and Frue vanners are also employed, and a special form of "end-shake" table is in use in the Silver Lake mill for saving the slimes. Where the ore to be treated is rich in galena the tendency in most of the newer mills is to substitute rolls for stamps. Huntington mills are frequently employed for regrinding tailings.

The richer ores, carrying free gold, require different treatment. In the thoroughly modern mill of the Camp Bird mine the equipment is similar to that which has been found best adapted to the free-milling gold ores of California. The ore passes from the crusher directly to the stamps, weighing 800 pounds and dropping 90 times a minute. The pulp passes through a 40-mesh screen to the amalgamating plates, where from 75 to 80 per cent of the value is caught. It is then passed through classifiers and over Frue vanners, the latter being so arranged that the pulp before being allowed to escape as tailings passes over two vanners. The ore commonly run through this mill averages from $100 to $200 per ton and is frequently much higher. The tailings run from $3 to $5, part of which is recovered in a small auxiliary mill.[1] Considering the peculiar character of the Camp Bird ore, which will be elsewhere described in this report, this showing is rather remarkable. Between mills of this type and the more complicated equipment required for treating lower-grade argentiferous ores there are all gradations, as will appear when each mine is described in detail. At the Tomboy mine, which produces a gold ore, the ore is crushed by rolls and ground in Huntington mills before passing over the plates, no stamps being used.

The various mills will be described in the detailed accounts of the individual mines included in this report.

The conditions under which the several mines operate differ so widely that it is impossible to assign a definite lower limit to the value of ores which can be profitably extracted. Ores ranging in value from $6 to $12 a ton are perhaps as of low a grade as can be now worked, even on a considerable scale and with modern equipment. For many of the smaller mines, however, this limit must be doubled. The Red Mountain mines were expensive to operate on account of the irregularity in the disposition of their ore bodies, their corrosive waters, and the necessity of pumping and hoisting through shafts. In 1888 the New Guston, then beginning operations on an extensive scale, paid dividends on ore mined at a cost of $53.50 per ton. The lowest annual cost per ton was $9.60 in 1894 on ore worth only $12.80 per ton. Location, power, timber, water, kind of country rock, and character and amount of ore form a complex set of factors, which fully accounts for the range in the limiting value between workable and nonworkable ore. Compared with $1.35 per ton, which in 1894 covered the entire cost of mining and treatment of the ore from the Alaska-Treadwell mine,[2] or the $2.50 to $5 per ton which covers the similar expense in many deep California gold mines, the figures given above seem high. But the difference is sufficiently explained by the difficulties inseparably connected with mining in so rugged and elevated a region and by the more involved processes required for the treatment of complex ores, the concentration of which is often rendered troublesome by the presence of sphalerite and barite, and which almost invariably require smelting.

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[1] In 1900 a modern cyanide plant was being erected to treat the tailings directly from the mill. It is now in operation.

[2] *Reconnaissance* of the gold fields of southern Alaska, by G. F. Becker: Eighteenth Ann. Rept. *U. S. Geol. Survey, Pt. III, 1898*, p. 64.

CLASSIFICATION OF THE ORE DEPOSITS.

The ore deposits of the Silverton quadrangle may be conveniently classified and described under three heads: (1) Lodes, (2) stocks or masses, and (3) metasomatic replacements. To the first class belong by far the greater number of the deposits that are being worked at the present time. To the second class are assigned most of the ore bodies formerly worked in the Red Mountain district, often locally known as "chimneys." In the third class, by far the least important in this quadrangle, are placed a few deposits occurring in limestone or in rhyolite.

In the classification of actual ore deposits it is usually found that a given ore body presents features common to two or more ideally distinct types. Thus a fissure vein may be accompanied by some replacement of the adjacent country rock, or it may be found impossible to draw any definite line between impregnation[1] and total metasomatic replacement. The present field offers no exception to this general difficulty, and the division of the ore deposits here made is not to be regarded as in all cases discriminating between totally different things. The aim is to group the deposits broadly, under most prominent characteristics of occurrence, in order that they may be conveniently and systematically described.

THE LODE FISSURES.

DEFINITIONS.

By fissure, as used in this report, there is meant a somewhat extensive fracture in the rocks. Such a fissure is not necessarily accompanied by recognizable faulting, nor by the production of visible open spaces, nor by mineralization. According to the classical definition of Von Cotta,[2] a vein is the filling of a fissure. As designating a simple type, of frequent occurrence, it seems very desirable that in accurate description the term vein should retain this significance, i. e., a "true vein" or fissure vein. In mining speech, however, the word commonly has a broader meaning, and is made to include not only the filling of a preexisting fissure, but also, in many cases, more or less altered and impregnated country rock alongside the fissure. Frequently the "vein" of the miner is a sheeted zone, embracing several veins in Von Cotta's sense, or it may be a zone of more or less irregular ore-bearing stringers. For this reason, lode will be consistently used throughout this report, as a more general term than vein, to designate either a simple filled fissure or a zone of closely spaced fissuring with possibly more or less impregnated or replaced country rock. Lode thus includes what Von Cotta and Von Groddeck[2] have called complex veins (zusammengesetzte Gänge).[1]

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[1] As used in this report, *impregnation* is merely a structural term indicating the fine dissemination of ore particles through a rock mass. In the majority of cases it involves true metasomatic replacement.

[2] Die Lehre von den Erzlagerstätten, 2d ed., Freiberg, 1859, p. 102.

A similar usage has been followed by Emmons and Tower[2] in their description of the ore deposits of Butte, Mont., and to some extent by Purington[3] in describing the ore deposits of the Telluride quadrangle.

DISTRIBUTION OF THE ORE-BEARING FISSURES.

Fractures in the rocks, containing more or less ore, are widely distributed within the quadrangle, but are larger, more abundant, or richer in metalliferous contents in certain limited districts than elsewhere. Prospects occur thickly dotted over the whole area, but the important mines are found in more or less isolated groups. A partial idea of the distribution of the fissures may be gained from the accompanying map (Pl. III), on which but a small proportion of the actual fractures are indicated. Moreover, in plotting the lodes the smaller, poorly exposed, and apparently nonworkable ones must necessarily be often disregarded, and the map can not therefore be taken as showing strictly the true distribution of all the fissures, but only of those which are superficially conspicuous or which carry ore in sufficient quantity to be worked or prospected. As the map suggests, fissures carrying variable amounts of ore are less noticeable features in the southwest and southeast corners of the quadrangle than elsewhere. But they occur in all the rocks which possess any considerable distribution within the area, from the Algonkian (or Archean?) schists, which constitute the basement formation of the region, to the latest monzonitic intrusions that cut the Tertiary volcanic series. By far the greater number of them, however, are found in the volcanic rocks of the Silverton and San Juan series. This is apparently due chiefly to the fact that these rocks occupy the greater part of the quadrangle rather than to any special determining factor in the rocks themselves. It is admittedly difficult, however, to isolate such a possible factor from others more directly associated with the origin and accumulation of these rocks than with their texture and structure. Whether the productive ore bodies that fill some of the fissures are as impartially distributed in the various formations as the fissures themselves is a different question and will be discussed in another place.

The existence of local areas of especially pronounced fissuring and mineralization has already been pointed out. Silver Lake Basin may be cited as a center of one such areal group of fissures. Not only are the fissures within and around this basin exceedingly numerous, but many of them contain large and productive ore bodies. Another area is that of Galena Mountain, where the fissures are well exposed and form a remarkable network, but have not hitherto proved to contain ore bodies of great value. As still other centers of conspicuous fissuring may be cited the heads of Treasure and Poughkeepsie gulches, Ross Basin, and Mineral Point. These last four local districts of vigorous fracturing are not distinctly separated, and should perhaps be included together as a single area over which fissuring and subsequent veining has taken place on an extensive scale. Finally, the region embracing Savage, Imogene, and Silver basins, in the northwest corner of the quadrangle, in which are located the Virginius and Smuggler-Union mines, may be regarded as part of a very important district of strong ore-bearing fissures, lying chiefly within the Telluride quadrangle.

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[1] Die Lehre von den Lagerstätten der Erze, Leipzig, 1879, p. 35.

[2] Geologic Atlas U. S., folio 38, Butte special.

[3] *Preliminary report* on the mining industries of the Telluride quadrangle, Colorado: *Eighteenth Ann. Rept. U. S. Geol. Survey*, Pt. III, 1888, p. 772.

COORDINATION OF THE FISSURES.

By the coordination of the fissures is meant their arrangement in natural systems, based upon direction, size, persistency, or other features. In the present instance the trends of the principal fractures will first be discussed, and afterwards the coordination of minor local groups of fissures occurring in various portions of the quadrangle will be considered.

If fissures were always vertical and were bounded by plane surfaces, it would be possible to represent them on a map, such as Pl. III, by straight lines. Moreover, a single careful observation along a short exposure of any fissure would afford sufficient data for accurately laying off the direction of the line on the map. It might then be possible to classify these fissures with mathematical precision and divide them into groups or systems, each system being characterized by a certain common direction.

But actual fissures seldom conform to these conditions. They stand at various angles to the horizon and are often curved. The existence of curves of large radii where it is evident that the mapped curvature is not the result of the combination of dip and topography is illustrated by several of the lodes plotted on the accompanying map, Pl. III. The existence of minor curves may be well seen in almost any plan of the underground workings of a mine exploiting a fissure deposit. These facts interfere materially with the discussion and classification of the fissures of a given region as a simple problem in plane geometry. It is obvious that single observations of the course of a fissure in a drift can not be assumed as giving its general strike. Nor is it practicable to tabulate such observations—at least in this region—and thereby to set up various systems of fractures traversing the region, each system narrowly confined and accurately distinguished from other systems by a difference of only a few degrees in trend.

In the Silverton region the important fissures have been mapped in the field with reference to the topography. The lines as shown are approximations to truth, requiring much allowance for necessarily limited observations and for imperfections of the topographic map.[1]

Inspection of the map on which the prominent lodes are thus platted shows that the most conspicuous fissuring has taken place in a general northeast and southwest direction. The dip of these fissures is usually southeast at about 75°. But the angles of dip range from 40° to vertical, and a few of the lodes dip northwest. Perhaps slightly less marked, but thus far more economically important, are numerous strong lodes running in a general northwest and southeast direction. In the southeastern quadrant these usually dip northeast at angles varying from 50° to 90°. Elsewhere they usually, although not invariably, dip southwest at high angles, as observed by Purington in the Telluride area. The existence of these two dominant directions was long ago pointed out by Endlich.[2] Purington,[3] in his description of the fissures of the neighboring Telluride quadrangle, concludes that "there are four general directions of fissuring: (1) East and west, and (2) northeast, best developed in the central and southeastern portions of the quadrangle, and (3) north and south, and (4) northwesterly, best exemplified in the northwestern portion." It will be seen that the two most prominent directions of fissuring in the Silverton area coincide with Purington's second and fourth general directions in the Telluride quadrangle.

There occur in the Silverton quadrangle several approximately north and south, as well as nearly east and west, lodes, and if attention were restricted to certain small areas, such as Galena Mountain, it might be considered advisable to recognize one or both of these directions as characterizing distinct subordinate systems of fractures. Such a grouping, however, while valid for the very limited area named, is lost when the various directions of all the fissures in the quadrangle are taken into account. The possible number of such subordinate systems then becomes so large as to obliterate the divisions between them. For accounts of these minor directions of fracturing the reader is referred to the latter part of this section, where their coordination is discussed, and to the detailed descriptions of the various local groups of lodes in the later pages of this report. It is sufficient in this place to point out that the fissuring of the rocks throughout the quadrangle has been so thorough and has taken place in so many directions that two of these only stand out as dominant. Even these show a certain localization within the limits of the quadrangle, the northeast-southwest fissures notably predominating in the northeast quadrant, while the northwest-southeast fissures are the more persistent in the southeast quadrant.

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[1] The topographic map upon which most of the lodes were originally laid down was partly revised during the year 1900, and these lodes had then to be transferred and adapted to the new map in the office a procedure which may lead to occasional unavoidable errors of position with reference to minor topographic features.

[2] *Hayden Survey, Ann.* Rept. 1874, p. 232.

[3] Loc. cit., p. 767.

In the accompanying diagram (fig. 1) the lodes represented upon the map have been platted as straight lines passing through a common central point. In the case of moderately curved fissures the line represents the average general direction. A few sharply curved lodes have been treated as if they were formed by two intersecting fissures, and represented in the diagram by two lines. The figure brings clearly before the eyes the great variety of direction assumed by the relatively few fissures which have been mapped as lodes. It fails, on the other hand, to express the relative persistency and individual importance of the various fissures represented, and in so far only partially brings out the prominence of the northeast-southwest and northwest-southeast lodes.

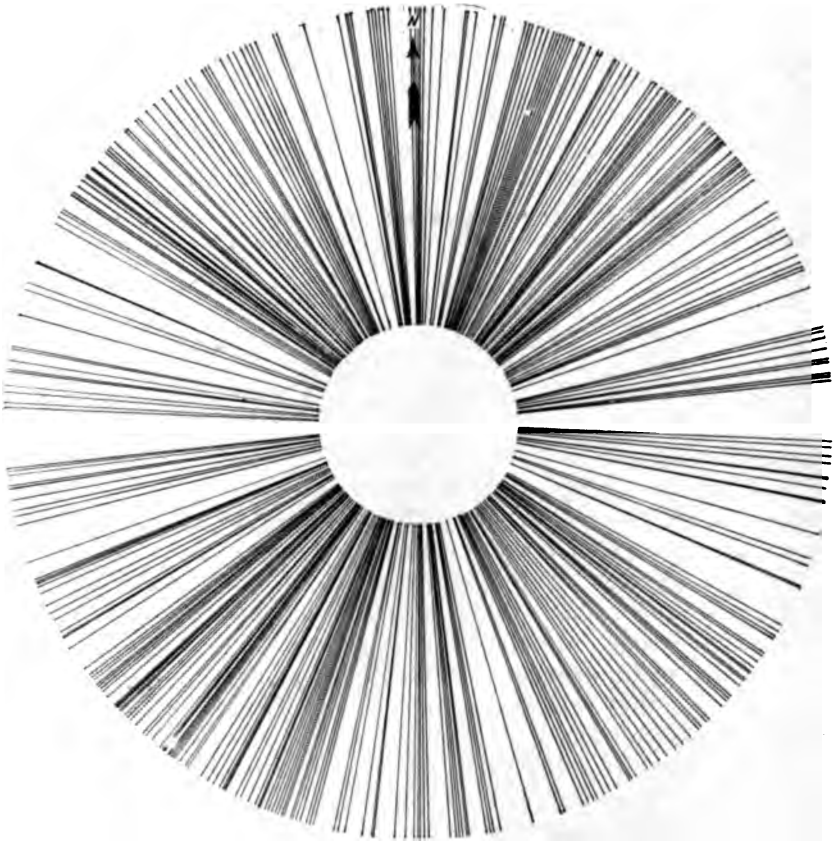


FIG. 1.—Diagram showing courses of some of the lode fissures of the Silverton quadrangle.

In a region traversed by such a great number of fissures, trending in so many different directions, it is not difficult to construct fanciful relationships. Few of the latter are more popular than that which makes all the important lodes radiate from one or more points—extinct volcanoes being generally preferred. That there is a certain radial disposition of the fissures will be presently shown, but this arrangement is very different from that which has been sometimes supposed, and which has been described in intendedly serious publications.

Having considered the various directions taken by the fissures in the region as a whole, it remains to discuss certain mutual relations in regard to direction exhibited by the fissures of several small areas. In spite of the wide diversity of strike already dwelt upon, and illustrated in fig. 1, it is nevertheless true that in certain limited portions of the quadrangular area one or more systems of fissures, characterized by fairly accordant directions of strike, are easily recognizable. In many cases these parallel fissures are so small and carry so little ore or vein matter that they have not been indicated on the map. Moreover, they are at places so closely spaced as to render it impossible to show them on the scale here employed for the topographic mapping.

On the west side of Silver Lake Basin, in addition to the productive lodes, such as the Iowa, New York City, and Stelzner, the country rock is traversed by a great number of smaller fissures, striking from 20° to 40° west of north, and resulting in a pronounced sheeting of the rock, generally parallel with the lodes mentioned, but without recognizable regular or rhythmical spacing. These fissures are nearly vertical, but one group of them sometimes exhibits a steep northeasterly dip, while another group dips southwesterly. Many of them are ore bearing, and it is not uncommon to see on a clean surface of rock a vein an inch or so wide composed of quartz and galena in about equal proportions. Such mineralized stringers may be seen to branch or to wedge out completely in a distance of 40 or 50 feet and be succeeded by an overlapping veinlet a few inches to one side. On a smaller scale they repeat the phenomena observed underground in the nearly parallel lodes, such as the New York City, belonging to Group II of the Silver Lake Basin lodes. (See detailed descriptions, pp. 145–148.) They appear to belong to the same system and to have been formed at the same time as the latter.

Two prominent sytems of parallel fissures, intersecting nearly at right angles, are noticeable in the cliffs at the head of Arrastra Gulch. One system, with a strike of about N. 32° W., and a dip of from 75° to 80° to the northeast, runs generally parallel with the trend of the gulch, and divides the compacted breccias of the Silverton series into great plates from a few inches to several feet in thickness. The width of this sheeted zone is from 30 to 40 feet. These fissures may perhaps be placed in the same system as those just described west of Silver Lake, and were possibly formed at about the same time. But they apparently contain neither ore nor quartz, and may be of later date. The second set of fissures, with a strike of N. 60° E., and a southeasterly dip of about 80°, crosses the gulch near its head, and may be seen also in Blair Gulch, in a considerably broader zone than the first set. Some of these fractures contain quartz, but, so far as observed, are not heavily mineralized and carry only a little pyrite. The relative ages of these two systems of intersecting fissures were not directly determinable in the field. It is not improbable that they were formed simultaneously as conjugate fissures. (See pp. 52–53).

Minor systems of fractures in parallel coordination may be well studied on Galena Mountain, a precipitous peak composed of both massive and fragmental andesite. The mass of the mountain is cut by very numerous fissures, many of them prominently indicated on the surface as lodes or veins. These may be divided into four groups, the members of each group being characterized by approximately the following strikes: (1) N. 45° E., (2) N. and S., (3) N. 25° W., and (4) N. 65° W. In each of these systems there usually occurs one or more fairly strong lodes accompanied by numerous smaller, nearly parallel, fissures, the rock being conspicuously sheeted. These associated parallel fissures are particularly abundant in the N. 25° W. system, as seen on the southern declivity of the mountain, in the vicinity of the Veta Madre mine. They are generally nearly vertical, and rather closely spaced, a foot or less apart. They are usually occupied by small veins which sometimes carry ore minerals, chiefly galena, sphalerite, and chalcopyrite, but which are seldom large enough or rich enough to be worked.

Another area within which the fissures exhibit striking parallel coordination is on Treasure Mountain and at the head of Placer Gulch. The dominant northeast-southwest fissure system of this portion of the quadrangle is exemplified by a series of strong, persistent lodes, represented by the Sunnyside and Scotia, with a general course of about N. 40° E. The dip of these is southwesterly at high angles. A second system of shorter, less conspicuous fractures crosses the first series almost at right angles, with a general course of about N. 55° W. These fissures are nearly vertical, but the majority of them dip southwest at high angles. In their trends these fractures belong with the system of northwest-southeast fissures already recognized as a system characteristic of the quadrangle as a whole. It is interesting to note that here, however, they are not, as in the Silver Lake Basin, the master fissures, but are short, transverse, relatively unimportant fractures, forming a nearly rectangular network with the strong, continuous northeast-southwest lodes. A third local system of transverse veins, represented by the Golden Fleece, has a course of about N. 75° E., with usually steep southerly dip. Still a fourth set of very prominent lodes is exposed at the head of Placer Gulch, with an average strike of about N. 25° E. Their dips are usually steep and easterly. There are several other fissures in this vicinity which do not strictly belong with any of the systems noted. Several have a nearly east-and-west strike, and might, perhaps, be grouped together or possibly included with veins of the Golden Fleece system.

In the canyon of the Uncompahgre, north of Mount Abrams, the thick masses of San Juan breccia and the underlying Algonkian schists and quartzites are cut by numerous nearly parallel fissures with a general trend of about N. 5° W. and a dip of about 80° to 85° to the east. These fractures, which do not, as a rule, contain prominent veins, have divided the San Juan breccia into huge, nearly vertical slabs (Pl. VII), and have thereby contributed to the preservation of the lofty cliff faces of this part of the canyon. A second, less prominent, system of fissures, usually carrying quartz stringers, has a general strike of about N. 60° W.

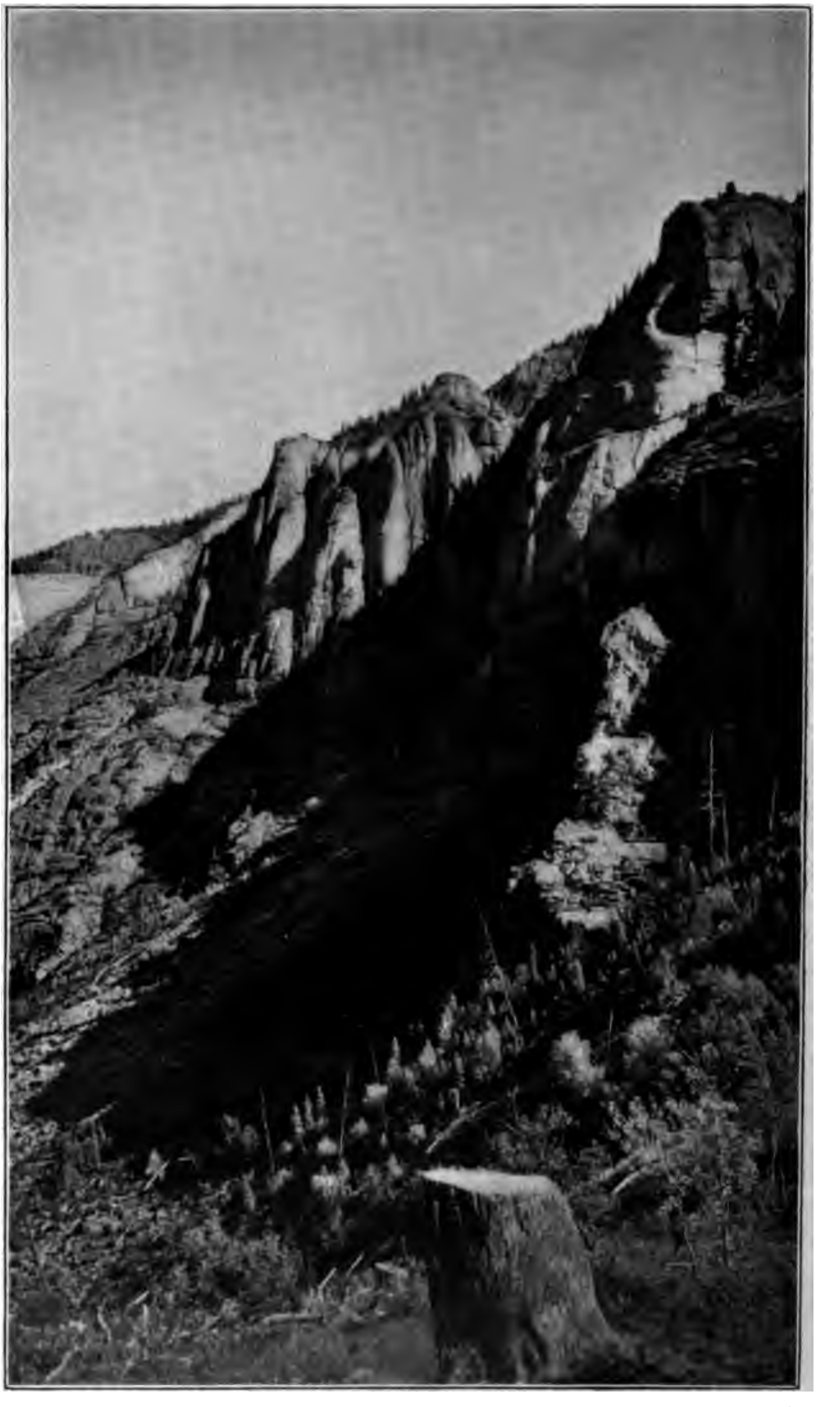
At the head of Porphyry Gulch, near the western border of the quadrangle, the Potosi rhyolite and underlying Silverton series are traversed by a conspicuous series of nearly vertical fissures, striking N 8° W., which do not contain workable ore bodies, so far as known.

A similar series of fissures is also very prominently shown in the steep walls of Canyon Creek northeast of the mouth of Richmond Basin. The general strike of these fissures appears to be about N. 35° W., and they usually dip steeply to the northeast. They belong genetically with the northwest-southeast system of lodes as developed in Silver Lake and Richmond basins. So far as is known they do not carry any workable ore bodies.

On the eastern side of Ironton Park are several fissures having a general northeast-southwest course and a steep southeasterly dip. Their formation was accompanied by considerable normal faulting.

The parallel coordinated fissures or sheeted zones hitherto described all possess considerable width and are characterized by the division of the country rock into slabs of relatively great thickness as compared with the resulting fissures. But this is not always the case. The fissures may sometimes be very small and also very closely spaced, as in the col separating Lake Como from Cement Creek, where the thorough manner in which the rock, a much-altered andesite or rhyolite, has been sheeted is beautifully shown. This minor sheeting is generally parallel in strike with the larger lodes in the vicinity, and at the particular point where best shown the fracture planes dip westerly at about 60°. As many as fifty such planes may frequently be counted within the width of a foot. There has been some infiltration of silica along these minute fissures, which causes them to stand out on weathered surfaces as little parallel ribs. The local strike of this sheeting is about N. 35° E., but it is sometimes disturbed by irregular later cross fractures. No regularity or rhythm could be detected in their spacing.

Sometimes several nearly parallel fissures of considerable extent,



SHEETED STRUCTURE IN CLIFFS OF SAN JUAN BRECCIA ABOVE THE SILVER LINK MINE. CANYON OF THE UNCOMPAHGRE RIVER

The breccia rests upon the eroded surface of Algonkian schists and quartzites. Photograph by Whitman Cross.

originally containing open spaces ranging from a few inches to a foot or more in width, occur closely spaced within a comparatively narrow zone bounded by less fractured country rock. Such a sheeted zone forms a favorable place for the deposition of ore bodies, and, as will be shown later, the Camp Bird, Tomboy, and other lodes are chiefly of this type, illustrated in figs. 9 and 14. Coordinate fractures of this simple character, in which the individual fissures maintain their individuality and essential parallelism for long distances, may pass without any line of demarcation into groups of fissures of the linked type, in which the nearly parallel fissures are arranged more or less en échelon and connected by smaller oblique fractures. This structure is exemplified to some extent in the Tomboy mine, but is not a common one in the Silverton quadrangle. With a still further shortening of the principal parallel fissures and an increase in the number and size of the linking fractures the fissure zone becomes a reticulated aggregation of irregular, curving fractures, which, when filled with ore, constitute what may be conveniently termed a stringer lode. Of this class is the North Star (King Solomon) lode. Finally, with yet greater increase in the number and irregularity of the fissuring, this type of fissure zone passes by insensible gradations into a breccia zone, such as a portion, at least, of the Polar Star lode.

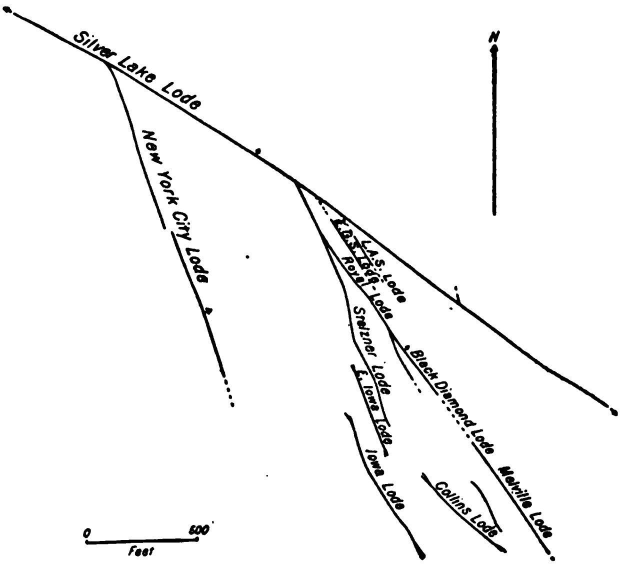


FIG. 2.—Horizontal sketch projection of the productive lodes west of Silver Lake.

Thus far the discussion has dealt with the parallel coordination of fissures into minor systems and with the steps by which such groups of fissures, when confined to rather narrow zones, may pass into other less regular structures commonly associated with the deposition of ore in lodes. It remains to consider another manner in which the fissures of this region are sometimes locally grouped, not in parallel, but in more or less radial, or, perhaps more accurately, branching, arrangement. This feature is well shown by the lodes of Silver Lake Basin. The accompanying diagram (fig. 2) is a horizontal sketch projection of the productive fissures worked in the Silver Lake and Iowa mines, compiled from maps of the underground workings. The relations of the lodes here shown are described on pp. 148–149, and it is only necessary in this place to call attention to the branching arrangement of the fissures and to the fact that all these lodes appear to have been formed at the same time. Another case of conspicuous branching occurs at the head of Placer Gulch, where several lodes having an average strike of about N. 25° E. split off from the main Sunnyside lode. The junctions in this case have not been exposed underground, but from the similar character of their filling it is highly probable that these fissures, like those of Silver Lake Basin, were all filled at the same time, and were therefore probably formed practically simultaneously.

Still a third and interesting case of branching fissures is that at Lake Como, partially and somewhat diagrammatically represented on the map (Pl. III). A view of some of these lodes is shown in Pl. VIII. In this instance, again, the lodes are all of similar character and all appear to have been formed contemporaneously.

Another mode of coordination sometimes observed in groups of fissures is that which Lindgren,[1] following Daubrée, has described under the name of conjugated fissures—i. e., in the particular region described by Lindgren, fissures having generally parallel strikes but dipping symmetrically in opposite directions. In the Silverton quadrangle, however, the fissures usually stand so nearly vertical that such a relation, if it exists, can not be clearly made out. The difference of dip, which would determine to which subdivision of such a conjugated system any given fracture would belong, is so slight, and may be so frequently found in various portions of one and the same fracture, that it does not seem practicable to recognize such systems. The low angle of dip at which most of the Grass Valley and Nevada City lodes lie makes the conjugated character of the fissure systems readily recognizable. It is to be noted, however, that in such conjugated fissures as those above described it is assumed that the rocks, in fracturing under tangential stress, yielded in a vertical direction, and that the prisms consequent upon the rupturing lie horizontal. But it is obvious that if, for some cause, the rocks could yield more easily in a horizontal direction, at right angles to the direction of thrust, then the resulting prisms would stand vertical and the conjugate fissures would, in this case, form two

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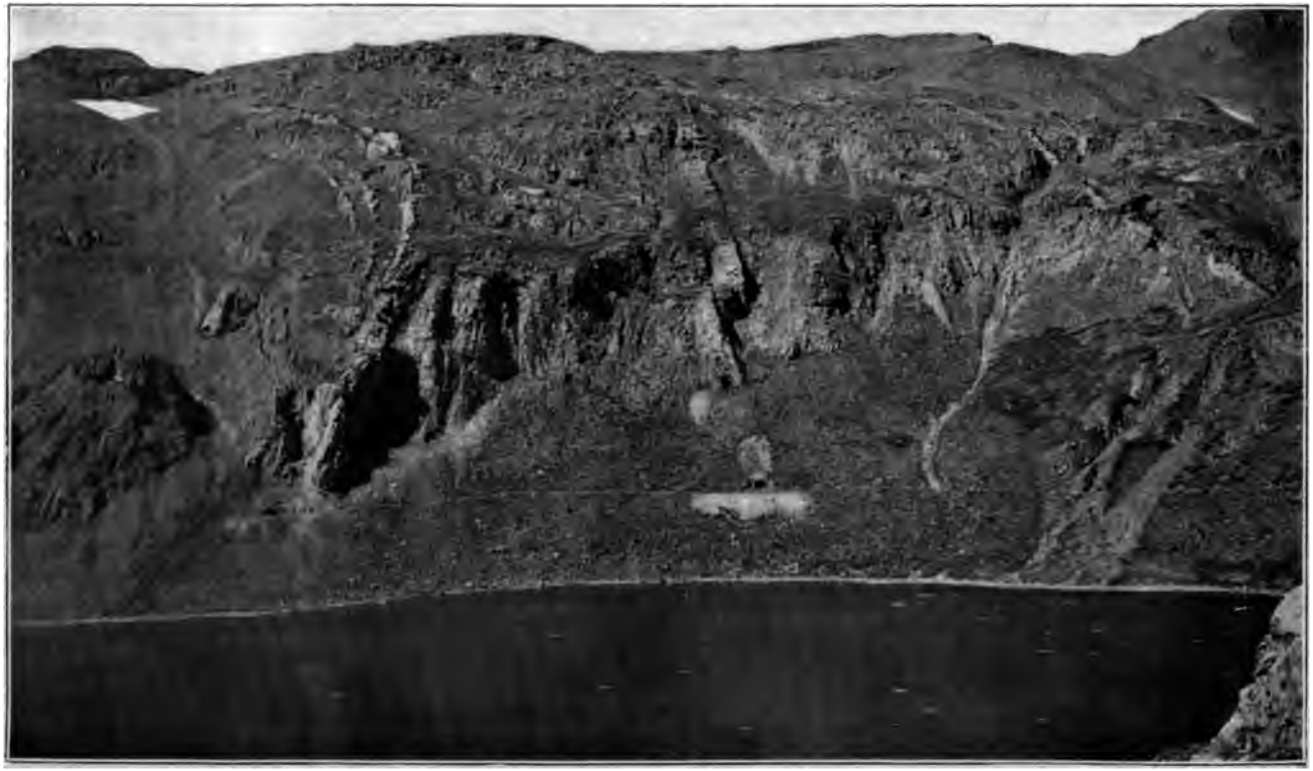
[1] The gold-quartz veins of Nevada City and Grass Valley, Cal.: Seventeenth Ann. Rept. U. S. *Geol. Survey, Pt. II.* 1896, p. 164.



VIEW OF LODES EXPOSED ON THE SOUTH SIDE OF LAKE COMO.

intersecting systems of vertical fractures, with their obtuse angles of intersection bisected by the direction of the applied stress. Thus systems of parallel fissures flatly dipping in opposite directions and systems of nearly vertical intersecting fissures may both result from compressive stress, and may both be called conjugated fissures. Further, all gradations are possible between these two extreme cases, dependent upon the relation of the present surface to the original direction of least resistance when the fracturing took place. It is quite possible that some of the steeply dipping fissures of the Silverton quadrangle which intersect nearly at right angles form conjugate systems in the sense of Daubrée. The test of this lies in determining whether the intersecting fissures are of the same or different ages.

RELATION OF FISSURES TO KIND OF COUNTRY ROCK AND TO ROCK STRUCTURE.

It has already been pointed out that fissures varying from greater or smaller widths occur in practically all the rocks found in the quadrangle. Opportunities are rare, however, for observing directly the character of the fissures as they pass from rocks of one kind to another, and when such observations are possible no marked change is apparent. It has been stated by at least one observer[1] that the lodes of this region occupy contraction fissures in the volcanic rocks, and do not extend down into the underlying schists or sediments. Nothing could be much farther from the facts than this assertion. Not only does the distribution of the fissures disprove it, but at the Green Mountain and Highland Mary mines, in Cunningham Gulch, the lodes may be seen passing from the Algonkian schists up into the overlying volcanic rocks of the San Juan and Silverton series. In the case of the Green Mountain mine no difference was noted in the fissure itself, either in width, direction, or general character, in the older schists and the younger rhyolite flow-breccia. The exact point at which the fissure passed from one rock into the other was not seen. The Highland Mary lode, where originally worked in Algonkian hornblende-schist, is a simple vein filling a clean-cut fissure 2 or 3 feet [illegible] toward the northwest the lode passes into the volcanic [illegible] San Juan and Silverton series, and becomes a rather irregular [illegible] about 12 feet wide where observed at a point [illegible] elevation above the mine. In general it is apparent [illegible] the fissures in the Algonkian rocks tend to be simpler [illegible] than those in the volcanic rocks of later age. The [illegible] the schists cleanly at various angles with the [illegible] apparently exercised no influence upon the direction [illegible] fracturing.

No [illegible] difference can be observed in the character of the fissuring within the various volcanic rocks of the quadrangle. It is very rarely possible to study in any one mine the passage of a given fissure from one rock into rock of a different sort, and thus the kind of observations which could best establish such characteristic differences, if they exist, is wanting. The massive lavas and indurated flow-breccias seems to have a general tendency toward comparatively simple fissuring, such as results in fissure veins of moderate size and regularity or in sheeted zones. In the softer tuffs and volcanic breccias the fissuring tends to be irregular, resulting in stringer or breccia lodes. Irregular fissuring appears to be favored also by alternations of harder and softer members of the nearly horizontal volcanic series, as at the North Star (King Solomon) mine. In this instance the softer rocks were regarded by the miners as the more favorable for ore. According to Purington,[1] in the northeast corner of the Telluride quadrangle the fissures passing from the San Juan formation and massive andesite up into the Potosi rhyolite series contain there less ore, and appear to have originally formed with less open space than in the underlying andesitic rocks. There are no workings in the Silverton quadrangle which afford an opportunity to verify this statement, but the Potosi rhyolite is generally regarded by the miners as unfavorable to ore in the region where it prevails. Near the head of Porphyry Gulch, however, a vein carrying galena and sphalerite ore up to 10 inches in width has been prospected in the Potosi rhyolite. The vein strikes N. 50° E. It can be followed for a short distance to the southwest, over the bare rhyolitic surface, when it either dies out or is cut off by a numerous series of small, nearly east-and-west fractures filled with white quartz and often showing excellent illustrations of linked-vein structure on a small scale.

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[1] [illegible] Vol. IV, [illegible] p. [illegible]

In the intrusive stocks of monzonite, such as that of Sultan Mountain, the fissures are, as a rule, of simple regular character and moderate width. They are usually occupied by fairly simple fissure veins, subject to local contractions or enlargements, but seldom lose their simple linear character. As examples, may be cited the fissures of the North Star, Hercules, and Little Dora veins in Sultan Mountain, and of the Hamlet vein near Middleton.

The foregoing generalizations are admittedly based upon scanty data, and are to be considered rather as suggestions indicating lines of future inquiry than as authoritative statements of facts.

As a rule, local geological structure has had very little discoverable influence upon the fissuring. The lack of any regular relation between fissures and schistosity has already been pointed out. Contacts between rocks of different kinds and ages also appear to have had but little effect upon the fracturing and subsequent veining. This is partly due to the fact that the contacts are frequently nearly *horizontal*, while the fissuring took place along nearly vertical planes.

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[1] *Eighteenth* Ann. Rept. U. S. Geol. Survey, Pt. III, 1898, p. 774.

Search was made in Cunningham Gulch, along the Uncompahgre, and at other points for any evidence of the diversion of fractures and mineralizing solutions along the contact of the older schistose terrane with the volcanic series, but with negative results.

Lines of fissuring in this region are occasionally determined by igneous dikes. Thus the Magnolia, a superficially prospected northwest-southeast lode just northeast of Silver Lake, follows for some distance an andesitic dike about 6 feet wide which curves across the gulch toward Round Mountain. Both this dike and a larger one which crosses it are irregularly fissured and traversed by poorly mineralized quartz stringers along the greater part of their exposed lengths. A similar occurrence was noted on the south side of Kendall Gulch about a mile a little east of south from Kendall Mountain, where a vein about 6 inches wide lies on the south side of a nearly east-and-west andesitic dike. None of these fissures have yet proved of much economic importance.

DISPLACEMENT OR FAULTING AS AN ACCOMPANIMENT OF THE FISSURING.

In a few cases only, and those of relatively unimportant lodes, has tangential dislocation been detected as a consequence or accompaniment of the original fissuring. The abandoned Moles mine, 3 miles south of Silverton, is on a vein about 2 feet wide which apparently fills a fault fissure of noticeable throw. The head of Deer Park Creek is crossed by a nearly north-and-south fault, with the downthrow on the west side, which is accompanied by some brecciation and veining of the schists along the fracture and with unimportant mineralization.

On the eastern side of Ironton Park, as shown in the Saratoga and Baltic mines, the formation of a parallel series of approximately northeast-southwest fissures has been accompanied by obvious faulting. These fissures, as a rule, dip steeply to the southeast. In all cases where it could be made out the faulting is normal, and the maximum throw, as observed on the Mono vein, can hardly be less than 100 feet. This fissure carries a body of low-grade pyritic ore.

In the northeastern portion of the quadrangle the field work of Messrs. Cross and Spencer appears to demand considerable faulting along some of the prominent vein fissures. But as there are no extensive underground workings in this portion of the area the evidences of such faulting did not come under my observation.

Notwithstanding the foregoing exceptions, it remains true that such displacement as occurred in connection with the formation of most of the principal productive lodes was slight in amount, although probably not wholly absent. Moreover, the peculiar branching arrangement of many of the fissures, described on page 52, and their disposition en échelon, as in the Silver Lake and Iowa mines (p. 157), would seem opposed to the idea that any considerable tangential displacement of the walls had taken place during their opening. In the King lode, south of Silverton, and in other fissures cutting the schists, there is no recognizable displacement or throw of the individual schistose bands by the fissuring. Slickensiding of the fissure walls prior to the deposition of the ore has been nowhere recognized. In the Telluride quadrangle, where the occurrence of workable lodes in nearly horizontal sediments gives better opportunities than are usually available in the Silverton area for detecting and measuring displacement, Purington[1] evidently saw little clear evidence of it. Beyond recording a vertical separation of 1 foot by normal faulting in the San Bernardo mine, and concluding from the shape of the ore bodies of the Virginius and Smuggler-Union mines that the spaces they occupy were probably formed by faulting of the same kind, he makes no further reference to faulting as accompanying the formation of the ore-bearing fissures, although pointing out the desirability of future study in this direction. In nearly horizontal rocks faulting in which the movement is confined chiefly to the horizontal component (offset or heave) is not readily detected when of small amount, and was noted only in the few cases in which later-filled fissures have cut productive lodes, displacing the latter.

The absence of considerable displacement as an accompaniment of the opening of lode fissures is not a special peculiarity of the Silverton quadrangle, but is of very common occurrence. In fact, it seems to be comparatively rare to find more than very moderate faulting in fissures which have formed productive lodes.[2]

INTERSECTIONS AND RELATIVE AGES OF FISSURES.

In a region where the fractures are so numerous and possess such diverse trends intersections must necessarily be of frequent occurrence. But as veins at such points are particularly susceptible to disturbance by later movements of the rocks and to superficial disintegration, the study of these intersections is often difficult. The presence of seams of clay or gouge, due to these later or postmineral movements and the entrance of oxidizing waters, may so obscure the original relationship at the junction of two fissures as to render any conclusive determination of relative age impossible when no conspicuous faulting of one of the fissures has taken place to give the desired information.

In many cases in the Silverton quadrangle intersecting fissures have been formed nearly or quite simultaneously and filled by one process of vein deposition. This is true of the assemblage of branching fissures worked in the Silver Lake and Iowa mines, and probably so of the Placer Gulch and Lake Como fissures. It is also possible that many of the fissures intersecting nearly at right angles (conjugate fissures) were produced by a single principal stress. In the greater number of instances, however, in which lodes are known to intersect, the exposures are such as leave the actual character of the crossing and the relative ages of the fissures in doubt. They may or may not have been simultaneously formed.

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[1] Loc. cit., p. 780.

[2] *Phillips and Louis*: A Treatise on Ore Deposits. London. 1896.

Fairly clear evidence of the intersection of an earlier vein-filled fissure by a later one without recognizable faulting was obtained at several points. The prominent lode outcropping along the crest of Green Mountain crosses and is distinctly younger than a strong vein of barren quartz, about 10 feet wide, which is accompanied by several parallel minor veins and strikes about N. 60° E., dipping 80° to 85° southeasterly. The younger lode has a general strike of about N. 30° W. and a steep southwesterly dip. The intersection is thus approximately rectangular, and is not accompanied by faulting, so far as could be seen. In the complex network of Galena Mountain it was found that at least one of the several north-and-south veins was cut by at least one of the numerous veins striking nearly N. 25° W., and these in turn are apparently intersected in several instances by lodes trending about N. 65° W. One of the latter was also observed to cut a lode striking about N. 30° E. In none of the cases mentioned was the intersection accompanied by visible results of faulting. Other probable examples of northwest lodes cutting northeast lodes occur on Treasure Mountain, but the exposures were not such as to place the question of relative age beyond doubt.

The shaft of the San Juan Chief mine was sunk at the crossing of two lodes, but it is by no means clear that they are of different age. The main lode, striking about N. 40° E., formerly produced some ore from surface workings. The fact that in their underground development the owners of the mine appear to have inadvertently drifted along the barren intersecting lode, striking about N. 60° E., is the only indication that the latter may be younger.

In three places only were lodes found to be faulted by later transverse vein-filled fissures. The King lode, in Cataract Gulch, 2 miles south of Silverton, with a strike of N. 6° W. and a dip of about 80° to the west, is faulted by a small approximately east-and-west quartz vein, dipping south at about 50°. By this faulting the northern portion of the King lode is thrown about 12 feet to the westward. In the Silver Lake mine the important New York City vein, with an average strike of about N. 20° W., and dipping generally northeast at about 80°, is cut by a faulting lode, which, where best exposed, is a breccia zone about 6 feet wide, composed of sharply angular fragments of country rock cemented by quartz carrying a little worthless ore. This fault fissure strikes apparently about N. 73° E. and dips about 75° to the south. The New York City vein is displaced in the same way and to about the same degree as the King lode. In the Ridgway mine the main lode, with a strike of about N. 40° E., is faulted by the Alaska lode, with an average strike of about N. 25° W. The fault here is apparently of the same kind as those just described—an offset of the northern portion of the main lode to the westward, but the developments in the Ridgway mine were not sufficiently extensive in 1899 to clearly show the relations. It is interesting to find that the three observed cases of faulting of one lode by another are of like character. In each case the lode running most nearly north and south has been faulted by barren or low-grade lodes trending more nearly east and west. While the number of observations is at present too small to serve for the formulation of a general rule for the quadrangle, their unanimity is suggestive of the possibility that such a rule may be laid down in the future. Even now, in the event that a productive lode in the southeastern portion of the quadrangle should be found, on drifting northward, to be cut off by a more nearly east-and-west lode with southerly dip, the miner, in the absence of other clues, is not utterly at a loss, but may reasonably hope to regain his ore by crosscutting westward after drifting beyond the interruption.

That, after the original deposition of the important ore bodies, there was at least one period of minor fissuring, followed by fresh deposition of quartz, is abundantly shown in many of the lodes of the region. Thus, in the Royal Tiger, the Dives, the Tom Moore, the Sunnyside, the Red Cloud, the Polar Star, and various other mines and prospects the original ore has been fissured or brecciated, and subsequently healed with generally barren or low-grade quartz. In the Tom Moore the later veinlets are notable in carrying small amounts of native copper in the quartz. This later fracturing is not always conspicuous, but small stringers of quartz, sometimes with rhodonite and carbonates, can usually be detected cutting the ore when the latter is examined in considerable masses. This is by no means a rare phenomenon in lodes in general, which are in most cases complex structures, resulting from successive fissurings and fillings. Such complexity, other conditions being the same, is more likely to be prominent in lodes of which the initial fractures were opened at an early geological period. The lodes of the Silverton quadrangle show much less evidence of repeated movements and filling than do the auriferous lodes of the Sierra Nevada, which were probably initiated at the close of the Jurassic or in early Cretaceous time.

Still younger than any of the fractures hitherto described are numerous fissures, usually noticeable only in mine workings in which neither quartz nor ore has been deposited. These are the "slips," "gouge seams," or "breaks" of the miners. As these names partly indicate, the fissures are generally filled with a wet, plastic, grayish clay, or *gouge*, which is, as a rule, merely altered and ground-up country rock, *resulting from the* attrition of the fissure walls. The presence of this *unctuous gouge*, when sharply limited by harder country rock or vein filling, is taken to indicate relative movement of the walls, not necessarily resulting in any great net displacement. In other words, they are fault planes of greater or less movement, possibly oscillatory. The width of these post-mineral fractures, as they are sometimes conveniently called, may vary from a narrow, scarcely noticeable clay seam, up to zones 12 feet or more in width, in which the gouge is mingled with masses of shattered country rock, and of which the most notable example is found in the zone of so-called "broken ground" in the Silver Lake mine (see p. 154). Occasionally the fine clayey material is lacking and the fracture is the course of a copious stream of water. Such a fissure was encountered in the Silver Lake mine in crosscutting to the New York City vein on level C, and the same or a similar water-bearing fracture was subsequently cut in the Unity tunnel about 400 feet lower. Since these post-mineral fractures can be studied, as a rule, only in the vicinity of the lodes, and as they are frequently directly connected with the latter, they may be conveniently classed as follows:

(*1*) *Strike fractures generally parallel with the lode.*—These are most commonly seen as gouges next the hanging or foot wall or in the country rock near to and approximately parallel with the lode in strike and dip. Gouge seams of this class, although not generally characteristic of the lodes of the Silverton quadrangle, are frequently well exhibited. They are found on both foot and hanging wall of the Silver Lake lode, particularly the latter, and also in the country rock for a distance of several feet on either side of the main fissure. When such later fractures have followed a previously existing vein or stringer they usually contain crushed vein quartz mingled with the gouge.

(*2*) *Strike fractures dipping at considerable angles with the lode.*—These are not so common as the foregoing, but sometimes occur. The ore in this case will be found to rest locally on a bench or step of country rock, separated from the latter by a clay seam of varying thickness. An example of this structure was noted in a stope on the Silver Lake lode (see p. 152, fig. 11). Such an occurrence needs to be carefully distinguished from the steps or benches of ore formed by the original opening of a somewhat irregular fissure by thrust faulting. In this case there should normally be no gouge between the ore and the country rock upon which it rests.

(*3*) *Cross fractures differing from the lode in both strike and dip, and cutting it at an appreciable angle.*—These are observed in nearly all extensive workings, and are sometimes fairly abundant and regular, as in the case of those which cut the Silver Lake lode (p. 151).

Besides the three classes noted, various irregular fractures occur in almost all lodes which can not be definitely grouped.

The post-mineral fractures are simply of local importance to individual deposits, and it has not proved practicable to discuss and classify them with reference to the quadrangle as a whole. Their possible bearing upon secondary enrichment of the primary ore deposits will be discussed in another part of this report.

To briefly recapitulate, while many of the fissures in the Silverton quadrangle, including some which differ widely in direction, were formed at substantially the same time, there have been later periods of fissuring, also followed by vein deposition. The oldest fissures known have a course somewhat east of north, and appear to have been successively cut by later fissures approaching more and more to an east-and-west strike. This generalization, however, should not be taken too rigidly, as it is very probable that whenever a prominent set of nearly parallel fissures were formed, other fissures intersecting the dominant set at various angles were produced at the same time. Lastly, there has been fissuring not followed, as far as known, by any deposition of quartz or ore in the resulting fractures.

The evidence afforded by the intersections as to the possible conjugate character of the dominant northeast-southwest and northwest-southeast fissures is unfortunately inadequate, owing to lack of satisfactory exposures of such junctions to determine the question one way or the other.

GEOLOGICAL AGE OF THE FISSURES.

Beyond the statement that the ore-bearing fissures of the Silverton quadrangle are of Tertiary and probably of late Tertiary age, it is not at present possible to fix the exact geological time at which the first considerable fracturing took place. More precise knowledge waits upon a determination of the exact age of the Telluride conglomerate and the San Juan and later volcanic formations. The Telluride formation, which, when present, underlies the volcanic rocks, has been provisionally referred to the Eocene by Cross.[1] It is difficult to conceive of its being older than this, as it has been found by Cross to rest unconformably on the Colorado Cretaceous shales. The Telluride formation and the younger volcanic series have been cut by several great intrusive masses of monzonite, such as the Sultan Mountain stock, which is thus the most recent rock in the quadrangle and can hardly be older than the Neocene. Since the lodes occur in the monzonite as well as in other rocks of the area, their formation probably does not antedate the latter part of the Tertiary, and may, indeed, have extended into the Pleistocene.

PROBABLE DEPTH AT WHICH THE PORTIONS OF THE FISSURES NOW EXPOSED WERE ORIGINALLY FORMED.

According to Cross,[2] the maximum thickness of the volcanic rocks in the Telluride quadrangle was, in round numbers, 5,000 feet. Owing to the varying thickness of different members of these series in the Silverton quadrangle, no very close estimate can be made of the average thickness of the volcanic accumulations over the quadrangle as a whole. It may provisionally be estimated, however, as from 5,000 to 6,000 feet. As no traces of any extensive later deposits have been found in the San Juan, it may be assumed that this thickness represents practically the total deposition from the beginning of Tertiary time. As most of the lodes worked at the present day occur within the volcanic series, and often from 1,000 to 3,000 feet above its base, it is evident that the portions of the fractures now accessible must have been formed at geologically moderate depths—that is, probably under 6,000 feet. When, further, it is remembered that erosion proceeded concurrently with the fissuring and probably made rapid headway during the progress of ore deposition, it appears that many of the ore deposits must have been formed well within depths frequently reached by mining operations. It might be expected that under these circumstances there would be a recognizable, although probably not very intimate, relationship between the ore as originally deposited and the present topographic surface. The full discussion of this subject, however, brings up questions whose solution properly belongs in another place, and which are treated in the section on the origin of the lode and stock ores.

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[1] *Geologic Atlas* U. S., folio 57, Telluride, Colorado; also Proc. Colo. Sci. Soc., Vol. V, 1894-1896. *pp. 235-241.*

[2] *Telluride folio.*

PERSISTENCE OF THE FISSURES HORIZONTALLY AND IN DEPTH.

Fissures are not of indefinite extent either horizontally or vertically. No fixed limit, however, can be assigned to the length which a given fissure may attain. It depends upon the magnitude of the stress that produced the fissuring and upon the relative movement which has taken place between the walls. Great relative movement results in a long fissure, but as profound faulting appears to be usually not favorable to the subsequent formation of a lode, there is a certain variable limit beyond which length is to be regarded as an unfavorable factor in the productiveness of a fissure lode. There are, however, certain notable exceptions to the foregoing general rule that should not be ignored. Thus the Merrifield-Ural lode, near Nevada City, Cal., occupies, according to Lindgren, a thrust-fault fissure of probably over 1,000 feet throw.[1] In the Silverton quadrangle fissures vary greatly in length. Those having a length of 2 or 3 miles are certainly not uncommon, and it is very probable that some of the fractures extend continuously for as much as 6 miles. That great length is not necessary for the formation of a productive deposit is shown by the occurrence of such lodes as the Iowa, Steezner, and East Iowa, which can scarcely be longer than a quarter of a mile, and which die out at their southern ends in small branching fractures. The exact length of a fissure is, of course, rarely determinable, as practical exploitation seldom follows a lode to its total disappearance.

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[1] Gold-quartz veins of Nevada City and Grass Valley districts; Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. II, 1896, p. 167.

The formation of fractures is limited vertically by that depth below which the rocks are under such pressure that no fissures can form. As the zone of fracture, according to Hoskins and Van Hise,[1] has a depth of about 10,000 meters (33,000 feet), and as fractures may also form in the still deeper zone of combined flowage and fracture, it is plain that this limit will never be reached in mining operations. But many fractures undoubtedly die out long before reaching this ultimate limit. The longer horizontal and the vertical dimensions of the fissures were probably originally nearly the same, and it is not likely that the present depth of any fissure very greatly exceeds its length. The depth will at least be roughly proportional to length. But the depth to which fissures extend is rarely actually determined, as the value of the ore body nearly always falls below the limit of profitable working long before the fissure itself disappears. But that many smaller fissures do die out at moderate depths is a well-attested fact.[2] In the Silverton quadrangle, where mining development is as yet restricted to moderate or slight depths, no well-authenticated case is yet known of the actual dying out in depth of a fissure which carried workable ore at a higher level. The ore may change in character, or may disappear, as in the North Star (King Solomon) mine, but the fissure still continues to an unknown depth.

In such instances as the last many considerations enter into the question as to whether it is advisable to follow the pinched fissure to greater depth in the hope of finding new ore bodies. The first step in such an issue is to determine whether the pinch is merely a constriction in a fissure extending to greater depth or whether it signifies the final diminution of the lode. This can be decided only by a careful consideration of the length and strength of the fissure as exposed above, of the possible faulting which accompanied its formation, and of the behavior of the fissure in those portions already mined. If the length of the croppings be several times the depth attained, if the fissure be usually strong, if it has been opened by faulting, and if it has been found subject to local pinches above, it may safely be concluded that it will persist and open out again with increased depth. But equally important is the question of the character of ore that may be found below, even if the fissure continue, for, as will be fully discussed later on, the ore contents of a given fissure are not constant at all depths, either in kind or in value. Lastly, in connection with these factors must be considered the costs involved in mining the ore from an increased depth.

The foregoing relates to simple fissures. Lodes in general exhibit similar characteristics, but their persistency will in the main be greater than that of a simple fissure. They are subject to the same general laws as the individual fractures of which they are composed.

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[1] Principles of North American pre-Cambrian geology; Sixteenth Ann. Rept. U. S. Geol. *Survey, Pt. I, 1896, p. 583.*

[2] *Lindgren, loc. cit.*, p. 162.

ORIGIN OF THE FISSURES.

The attempt to explain the origin of so complex a network of fissures as occurs in the Silverton quadrangle presents many difficulties. No explanation that can be at present proposed is to be regarded as complete or as free from various necessary assumptions. Our knowledge as to the degree of homogeneity of the various rock masses under strain, the depth at which the fissures were originally formed, their exact extent, direction, and distribution, the geological conditions obtaining at the time of fissuring, and numerous other essential data are far too fragmentary to permit of anything like rigid analysis leading to irrefutable results. And yet the problem is not so hopelessly insoluble but that it may be reasonably taken up in the hope of finding at least a working hypothesis to account for major features.

Fissures in which ore deposits occur are very commonly regarded as produced by tangential compressive stress transmitted in nearly horizontal planes by the rocky envelope of the earth, within what Van Hise[1] has termed the zone of fracture, limited by a depth of 10,000 meters. In many districts this is, without much doubt, the immediate cause of the fracturing. Thus, in the Grass Valley and Nevada City region of California the conjugated systems of flatly dipping regular lodes, opened with the accompaniment of more or less thrust faulting, were probably, as Lindgren concludes, "produced by a succession of compressive stresses applied in different directions, chiefly from east to west and from north to south."[2]

In accounting for the fissures of the Telluride quadrangle, Purington[3] arrived at somewhat similar conclusions. He states:

> From all observed phenomena it seems probable that the fissuring was made by forces acting at time intervals not far apart and at localities not far removed from one another. Since the fissuring is later than all the rocks of the quadrangle [Telluride], volcanic disturbances whose product is now visible can not be cited to account for it, but it is entirely possible that later disturbances of volcanic nature, which did not result in surface flows of lava, have produced a straining to the point of rupture in the tract under consideration. It is thought, with great reason, that in the area directly east and northeast of the Telluride quadrangle there are centers and necks of volcanic eruption. Such evidence as has been collected in the present investigation points to those quarters as the source from which the pressure came.

Since the fissures of the Telluride and Silverton quadrangles were formed at the same time and undoubtedly had a common origin, Purington's results have an important bearing on the problem in hand, and it becomes necessary to scrutinize them closely. The geological mapping of the Silverton quadrangle and reconnaissances to the north of it, accomplished by Cross and Spencer since Purington's report was written, have failed to identify the actual "centers and necks of volcanic eruption" referred to as the possible sources of the compressive stresses supposedly effective in fissuring the rocks of the Telluride quadrangle. There is, however, ground for believing that there may have been local manifestations of volcanism in the Red Mountain region. It is not impossible that the plug-like masses of porphyry mapped by Mr. Cross (Pl. IV) may occupy conduits through which volcanic materials reached a former surface some thousands of feet above the present one. The character of the ore deposits, the intensity of the associated metamorphism, and the geological distribution of the Tertiary volcanic rocks all strongly suggest that one or more centers of former volcanic activity underlie the Red Mountain region. This, of course, does not mean that any trace of volcanic form remains in the present topography. Cones or craters, if they existed, have been obliterated in the evolution of the erosional forms of to-day.

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[1] Loc. cit., p. 589.

[2] Loc. cit., p. 170.

[3] Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. III, 1898, p. 770.

In the Silverton, however, no less than in the Telluride area, the greater part of the fissuring is not only post-volcanic, but is later than the monzonitic intrusions which cut the volcanic series. Thus, although the vast volcanic accumulations of the San Juan must have issued from local vents, the reference of the forces which produced the fissures to one or more centers of eruption immediately east or northeast of the Telluride quadrangle as their source is as yet scarcely warranted by the facts. In this connection it may be noted that the intrusion of the great stocks of mozonite into the rocks of both quadrangles brings up the rather perplexing problem of the mechanics of such intrusions and the disposition of the rocks which formerly occupied the space now filled by the intrusive mass. He would be rash who would assert that the intrusion of these stocks was not accompanied by strains and fissures in the surrounding rocks, and yet the fact is clear that the principal ore-bearing fissures of the region were formed after the monzonite had solidified, since they cut the latter as well as the adjacent formations.

But leaving aside for the present the question of their source, it is necessary to investigate more fully the extent to which tangential stresses of the kind indicated may be regarded as an effective cause of the fissuring of the Silverton quadrangle. Normally, in homogeneous rocks, such stresses might be expected to produce systems of conjugated fissures of parallel strike, with dips not far from 45°, and accompanied by some, although not necessarily great, thrust faulting; i. e., reversed faulting. The actual fissures do not conform even approximately to these conditions. Assuming that the direction of least resistance was vertical, it is inconceivable that fissures so nearly vertical and showing so little evidence of thrust could have been formed by tangential stress. Moreover, such evidence of faulting as Purington was able to obtain in the Telluride quadrangle indicated normal faulting and not thrust faulting.

If, on the other hand, the direction of least resistance was not vertical, but horizontal, then tangential stress might produce systems of nearly vertical fissures intersecting nearly at right angles conjugate fissures. As shown by Daubrée's[1] classic experiments, such fractures would be undulating, not strictly parallel, and might branch as do the fissures of the Silver Lake Basin. Moreover, as shown by Daubrée's illustrations, the walls of such fissures will not necessarily be always slickensided, nor need the faulting be in all cases perceptible. Such faulting as took place would result mainly in horizontal displacement, or offset, and, not being necessarily great in amount, might be easily overlooked. It is possible in this way to account for much of the fissuring of the Silverton quadrangle, and perhaps this view best explains the two dominant directions of fissuring intersecting nearly at right angles.

This hypothesis that the dominant northeast-southwest and northwest-southeast fissures were formed by compressive stress, acting nearly horizontally, although the direction of least resistance which it presupposes is not that which would appear most probable, seems to offer fewer serious objections than any other that has been devised. Fissures of contraction they certainly can not be, for they cut indifferently rocks of most diverse age, character, and origin. Fissures originating from tensional strains would probably be more irregular and would not be associated with close parallel sheeting of the rock. Tension would find relief in a single fissure rather than in a series of closely spaced parallel fractures. Shearing strains due to differential elevation or subsidence might culminate in fissures, but these could not be expected to show the general regularity and the persistency of the principal fissures of the Silverton quadrangle, and would probably reveal evident faulting. Faults probably due to such forces occur within and about the quadrangle, but they rarely contain ore deposits. Torsional stress, which by Daubrée[2] is regarded as a system of pressures, and by Becker[3] as a system of tensions, is capable of producing systems of parallel fissures intersecting at nearly 90° as well as radial fissures. It may at times be impossible to distinguish such fissures from those formed by simple pressure. But the fissures produced by torsion are in general decidedly curved, with a more strongly marked radial disposition. Their characteristics are given in detail by Becker in the paper cited. In a homogeneous block subjected to pressure, there are formed, in addition to the main conjugate fractures, various more or less irregular fractures, making angles of less than 45° with the direction of pressure, and frequently branching from the main fissures (see Daubrée, loc. cit., Pl. II). Such fractures are comparable with the branching fissures of Silver Lake Basin and Placer Gulch. For this reason, and on account of the preponderance of nearly north-and-south fractures over nearly east-and-west fractures, it is thought that the effective stress producing the principal fissuring of the quadrangle may have acted in a north-and-south direction. Further, since there is no known source of such stress exterior to the quadrangle and immediately adjacent region, it is thought probable that the stresses were generated chiefly within the quadrangular area, by slight vertical movements following the enormous transfer, in Tertiary time, of volcanic material from an intratelluric to a superficial position, and that the surrounding country merely acted as a relatively passive buttress against which the thrust was directed. In other words, it is believed that the stresses were due principally to local gravitative readjustment. Some genetic connection between the volcanism and the subsequent fissuring, mineralization, and veining can scarcely be doubted, as these phenomena rapidly diminish in intensity away from the volcanic district of the San Juan Mountains. It does not seem possible at present to do much more than suggest that hypothetical relation which seems to adhere most closely to the known facts.

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[1] Études Synthétiques de Géologie Expérimentale, Paris, 1879, Pl. II.

[2] Loc. cit., p. 321.

[3] Torsional theory of joints: Trans. Am. Inst. Min. Eng., Vol. XXIV, 1894, p. 137.

In addition to the principal stress outlined, there were doubtless many minor directions of stress set up at various times, some contemporaneous with the principal north-and-south stress and others earlier or later, frequently leading to the production of minor local fissure systems. These also were probably in part compressive tangential thrusts, and it is the existence of these widely differing directions of effective stress that furnishes one of the strongest arguments against seeking sources for the latter outside of the region itself. It is exceedingly improbable that there should have been set up at various widely separated points in the relatively undisturbed regions inclosing the volcanic area, stresses which were to find their most energetic expression in the fissuring of the area itself. It seems likely that torsional strains also had their place in the readjustments following volcanism. Such a complex of fissures as that around Lake Como seems hardly to admit of any other satisfactory explanation. The probability that torsion has been a factor in the minor fissuring of this region has been suggested by S. F. Emmons.[1] It seems not unlikely that earthquake shocks, to which there is good reason to suppose the region was subjected during the faulting and principal fissuring accompanying post-volcanic readjustments, may have, in some instances, transformed torsional strain into actual fissuring, as suggested by Crosby.[2]

In conclusion, it may be well to recall the complex forces and results that enter into the fissuring under simple pressure of a block of what is commonly called homogeneous material. The geological conditions under which rocks are fractured are vastly more complex, and, as Dr. Becker[3] has remarked, "it is entirely safe to presume that every possible mode of deformation and rupture is exemplified," and, it may be added, frequently in a single limited field of fracture. The best that can be hoped for in any case is to ascertain the *dominant* mode in which fracturing has taken place.

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[1] Structural relations of ore deposits: Trans. Am. Inst. Min. Eng., Vol. XVI, 1888, p. 804.

[2] The origin of parallel and intersecting joints: Am. Geol., Vol. XII, 1893, p. 368.

[3] The torsional theory of joints: Trans. Am. Inst. Min. Eng., Vol. XXIV, 1894, p. 130.

STRUCTURES OF THE LODES.

The larger structural features of the various lodes depend mainly upon the character of the fissures in which they were deposited. Where the original fracture was a simple, clean dislocation, the resulting lode is a fissure vein. Most of the lodes of the Silverton quadrangle are of this character—nearly vertical plates of gangue and ore confined between definite walls. They sometimes show local irregularities and may divide into numerous branching stringers (stringer lodes) at their edges, but in the essential character of their workable portions they are veins, in the original sense of Von Cotta. Such are the veins of the Empire group on Sultan Mountain, the New York City (fig. 3), Stelzner, Royal, and Iowa veins of Silver Lake Basin, the Green Mountain vein, most of the veins of Galena Mountain, the Hamlet vein, and many of the lodes in the northeast portion of the quadrangle. The width of the workable veins usually varies from a few inches up to 10 or 12 feet. Lodes attaining greater width than this are rarely simple veins, although some of those near Sunnyside Basin, with widths of from 30 to 50 feet, appear to have filled, simple open fissures. A width of 2 or 3 feet is perhaps a rough characteristic average of the productive veins of the Silverton region. The vein filling usually fits snugly to the fissure walls and is frequently adherent to them—"frozen," as the miners say. Quite commonly, however, there has been sufficient movement along the fissure to cause the ore to come away readily from one or both walls, and sometimes there is a gouge or selvage present. This is rarely thick or extensive. Fissures sometimes contract, or pinch, and the vein then becomes much reduced in width and may be entirely absent. Such pinches, where the fairly solid walls are separated by a mere crack, were encountered on the New York City, Stelzner, and other veins, and on the Camp Bird lode. It is often difficult, when such a pinch is passed through by a crosscut, to believe that it really represents a lode which is elsewhere wide and productive. Many crosscut tunnels have on this account overshot the vein sought for. Careful systematic surveying and mapping is the

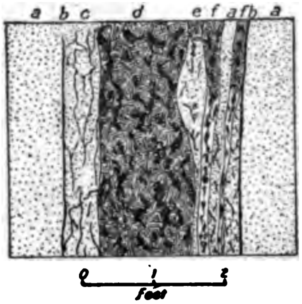

FIG. 3.—Cross section of the New York City lode, Silver Lake mine. *a*, country rock; *b*, miners' wall; *c*, broken country rock; *d*, ore, chiefly galena, chalcopyrite, and sphalerite; *e*, ore and country rock; *f*, ore and quartz.

safeguard against such mishaps and is the prerequisite of all intelligent and extensive prospecting.

As a rule the country rock adjoining the veins is not strikingly altered and retains practically the original form of the fractured surfaces. In some veins in rhyolite, however, there has been some replacement of the rock by ore, as may be seen in the Tom Moore mine.

Veins of the simple type described are connected by many transitional forms with lodes occupying closely spaced sheeted zones and consisting really of several parallel veins. Such are the small lodes of the Micky Breen and the important lodes of the Camp Bird and Tomboy mines. In both the Camp Bird and Tomboy, however, the parallel veining resulting from sheeting of the country rock is associated with the less regular linked-vein structure, in which the lode is made up of nearly parallel or slightly diverging veins connected by linking stringers (Trümmer) and with the yet more irregular stringer-lode structure, in which the lode consists of a mass of stringers without noticeable parallelism among themselves. In these mines the more regular structure is usually found with the gold ore separated from the hanging wall by a little gouge, while the more irregular structures characterize the foot-wall portion of the lode, carrying a low-grade galena ore and sending off irregular stringers into the country rock, and being thus without regular foot wall.

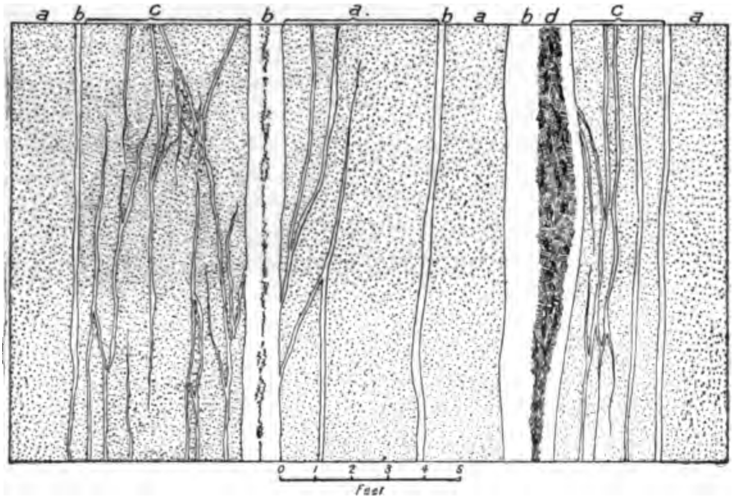

FIG. 4.—Sketch section of the Silver Crown lode, showing stringer-lode structure. *a*, andesite; *b*, quartz; *c*, andesite and quartz stringers; *d*, ore.

The stringer-lode structure is perhaps best exemplified in the North Star (Solomon) lode, in portions of the Royal Tiger and of the Pride of the West lodes, in the upper part of the Forest lode, and in the *Alabama* lode. But it may frequently be well studied in surface outcrops, notably those which stand out on the steep slopes of Dome Peak, north of Howardsville, and in particular near the head of Mill Creek, west of Chattanooga, where the Silver Crown lode is beautifully exposed in the bed of the stream, and the details of its structure may be seen through the clear water. Fig. 4 is a sketch of the lode as seen at the bottom of a clear pool in the creek. In minor development it is to be seen in nearly every fissure deposit in the quadrangle. The most regular of the veins will sometimes locally split up into a stringer lode, particularly where the fissure is seen about to die out in the country rock.

Breccia lodes—that is, lodes in which the ore and gangue originally filled the spaces in a zone of brecciated country rock, do not appear to be common. The only deposit seen which would appear to be characterized chiefly by this structure is that of the Silver Queen mine on Bear Creek, near the northern edge of the quadrangle. Here the pay streak, from 3 to 6 feet wide, lies in a brecciated zone about 12 feet wide in the San Juan formation. Judging from the materials seen on their dumps, the Polar Star and Red Cloud lodes also were in part deposited in breccia zones.

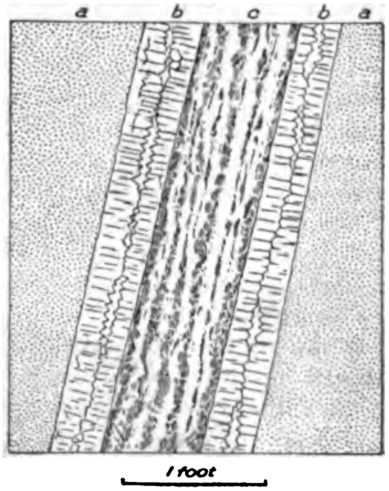

Fig. 5.—Cross section of the Japan lode, showing structure produced by successive openings of the original fissure. *a*, country rock; *b*, quartz; *c*, ore.

To a certain extent the lodes as originally formed have had their structure modified by later movements, resulting in fractures in the ore already deposited, followed by a secondary veining, usually of quartz. It could not be proved that this process has exerted any important influence upon the ore. As a rule the secondary stringers are small and relatively barren. In the Tom Moore lode the later stringers carry a little free copper, but the amount is insignificant from a commercial point of view. In the Polar Star and Red Cloud mines an earlier deposition of quartz carrying pyrite was certainly brecciated and followed by renewed veining. But there was no means of determining in 1899 to which period of deposition the ore of these mines belonged. The Japan lode, a section of which is shown in fig. 5, appears to have been formed by successive openings of the original fissure. The main ore streak of banded galena and sphalerite ore was first deposited. Later, nearly barren white quartz, with well-marked comb structure, was deposited in fresh openings on each side of the original vein.

The internal structure of the fissure fillings, such as banding and comb structure, and the size and shape of pay shoots, while, strictly speaking, embraced under the head of lode structure, will be more conveniently described in the following sections on the ores of the lodes.

THE ORES OF THE LODES.

MINERALOGY OF THE ORES.

GANGUE MINERALS.

Under this head are included those mineral constituents of the lodes which commonly make up the matrix of or are intimately associated with the metallic ore minerals. The term is a somewhat relative one. Thus pyrite is often a matrix for free gold, and has sometimes been treated, with chalcopyrite, etc., as a gangue mineral.[1] But in the present report the term gangue will be restricted to the so-called nonmetallic minerals,[2] chiefly oxides, carbonates, sulphates, and silicates, while the compounds of the heavy metals, largely sulphides, sulpharsenites, sulpharsenates, sulphantimonites, or sulphobismuthites, all commonly possessing metallic luster, will be treated as ore minerals, although they may not in all cases be valuable. This is but following the convenient distinction laid down by such classical writers on ore deposits as Von Cotta and Von Groddeck, and is in accordance with the usage of Lindgren,[3] Phillips,[4] and others.

In the brief résumé of physical properties given with each mineral, the aim has been simply to give those features of color, form, etc., which will enable one to recognize the minerals as they occur in this particular quadrangle. The same minerals occurring in other regions may differ in the properties named.

Quartz.—SiO_2. Rhombohedral. Massive, or in hexagonal prisms terminated by rhombohedrons. Usually white or colorless. Hardness, 7. Specific gravity, 2.6.

This, as a rule, exhibits the usual character of vein quartz common in most mining districts. It varies from semiopaque, milk-white varieties to those which are vitreous and transparent. The latter occur in the Camp Bird and Tomboy lodes carrying free gold, usually in minute particles. In the Tomboy the occurrence of the gold in quartz of that particular vitreous appearance which is elsewhere commonly regarded as a sign of worthless vein matter has been commented upon by Purington.[5] The quartz of the veins is generally massive, and in thin section under the microscope is seen to be com-

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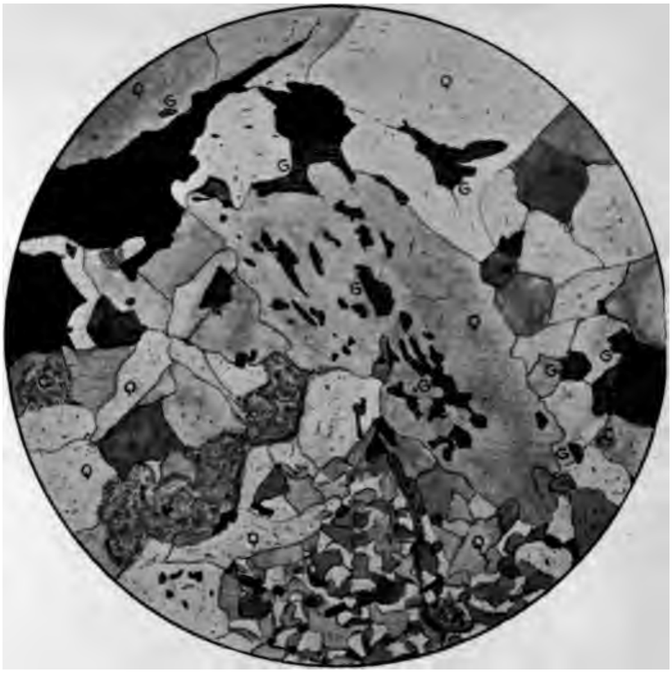
[1] Mining industries of the Telluride quadrangle, Colorado, by C. W. Purington: Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. III, 1898, p. 781.

[2] Von Groddeck, Lagerstätten der Erze, p. 58, Leipzig, 1879.

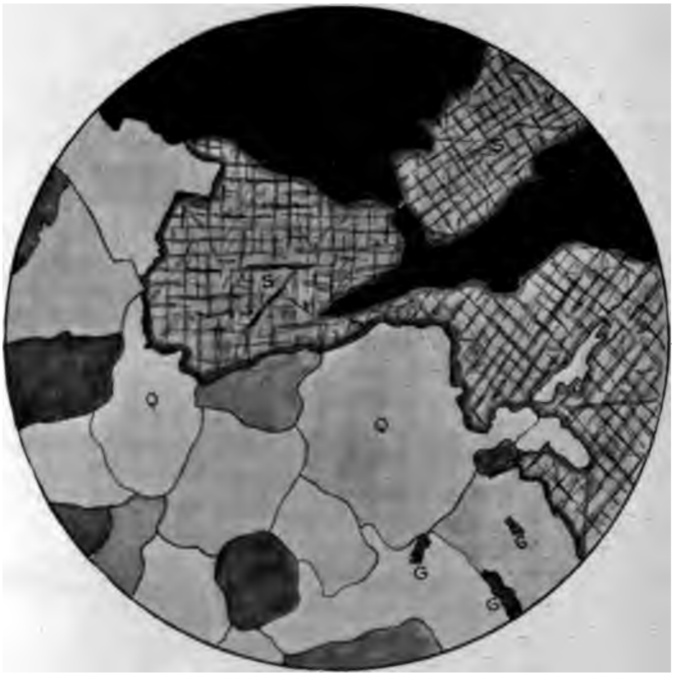
[3] Gold-quartz veins of Nevada City and Grass Valley districts: Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. II, 1896, pp. 114-119.

[4] *Treatise on Ore Deposits*, 2d ed., pp. 1-2 and 85, London, 1896.

[5] *Loc. cit.*, p. 840.



A. Stelzner lode.



B. Sunnyside lode.

NORMAL VEIN-QUARTZ STRUCTURE.

Magnified 17 diameters; nicols crossed; black areas, chalcopyrite; Q. quartz; C. chlorite; G. gale
S. sphalerite.

posed of interlocking grains with incomplete crystal boundaries (see Pl. IX, *A* and *B*). Distinct crystals are found only in small vugs and are never of large size. A radial arrangement of the imperfectly formed crystals was noted in the Dives, Magnet, Camp Bird, and Tomboy mines. The quartz of the Silver Lake lodes frequently incloses chlorite, which gives it a green color, usually regarded as an indication of good ore. In some of the lodes the presence of minute included crystals and grains of galena, sphalerite, tetrahedrite, argentite, various sulphobismuthites, and other ore minerals results in a dark-clouded quartz in which the ore minerals are not recognizable with the naked eye. Such is the richest ore of the Ridgway mine (Pl. X, *A*). Microscopic fluid inclusions are common, usually with gaseous bubbles. They are frequently arranged along irregularly disposed curved surfaces in the quartz.

In addition to quartz of the foregoing character, which has crystallized in open spaces, there occurs within and adjacent to many of the lodes, and especially in connection with the stocks of the Red Mountain district, a much more finely crystalline quartz, sometimes resembling a fine-grained quartzite, which has resulted from a partial or complete replacement of country rock by silica. As seen in thin section under the microscope, this quartz is associated with more or less sericite or kaolin, and sometimes alunite, in a cryptocrystalline mosaic. Such a mosaic often reveals the outlines of the former crystals of feldspar, which have been metasomatically replaced, as more fully described on pages 114–131.

As vein filling, with other gangue minerals and ore, quartz occurs in nearly all the productive lodes of the quadrangle, but the relative amount of quartz and ore minerals varies widely between the highly siliceous gold ore of the Tomboy, showing to the eye insignificant mineralization, to the coarsely crystalline, heavy lead ore of the Royal Tiger and Iowa mines. In a few of the lodes occurring in rhyolite, vein quartz may be practically absent. It did not occur to any considerable extent with the ore stocks of the Red Mountain district, where the quartz is chiefly the result of metasomatic replacement of the country rock.

Barite.—BaSO$_4$. Orthorhombic. Massive, or in groups of diverging tabular crystals. Cleaves perfectly in three directions. White. Transparent to opaque. Hardness, 3. Specific gravity, 4.5; whence common name "heavy spar."

This is not nearly so important a gangue mineral in the Silverton quadrangle as quartz, but it occurs massive with the latter mineral in the veins in the Sultan Mountain monzonite mass, in the Royal Tiger, Melville, and probably other lodes in Silver Lake Basin, as a heavy vein in the Dives and Potomac claims, in the veins of Galena Mountain, where it has sometimes been replaced by pseudomorphous quartz, and in the Bonanza, Alaska, Tempest, Alabama, Old Lout, and other lodes in Poughkeepsie Gulch. In practically all the stocks of the Red Mountain district barite was found in close association with the argentiferous copper ores. Thus in the Guston and Yankee Girl the bornite or chalcocite often incloses numerous isolated crystals of translucent barite, and it is to be found on nearly every mine dump in this vicinity. It also occurs in the Zuñi mine, on Anvil Mountain, embedded in kaolinite, and with zunyite in guitermanite. Where occurring in lodes, the barite is very commonly associated with gray copper (tetrahedrite). In the Mastodon claim, on the Sunnyside lode, barite forms with quartz a finely crystalline aggregate which constitutes the gangue of a highly argentiferous lead sulphobismuthite.

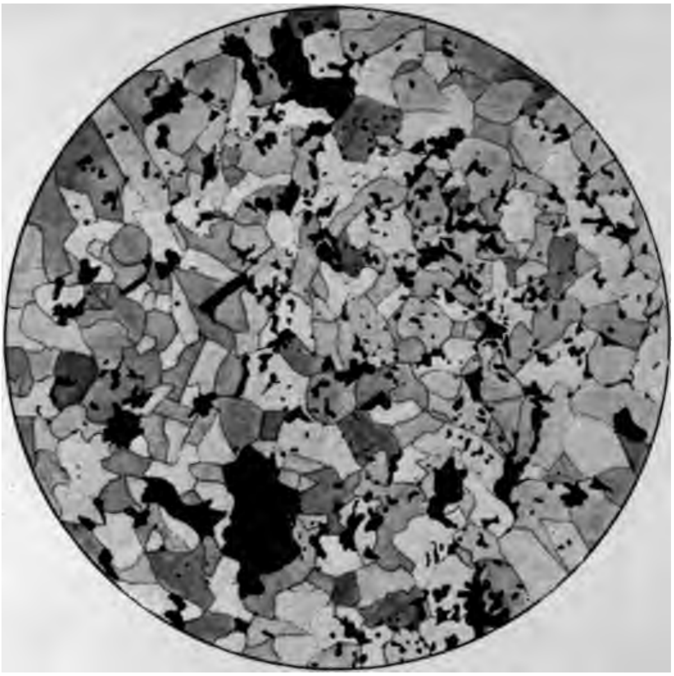
Calcite.—$CaCO_3$. Rhombohedral. Commonly massive or in rhombohedrons, scalenohedrons, or prisms. Cleaves perfectly in three directions, affording rhombohedrons. White. Transparent to opaque. Hardness, 3. Specific gravity, 2.71. Effervesces freely with cold dilute acid.

Calcite is less abundant than barite in the productive lodes, but is nearly always present in small amount, particularly in small vugs and in minute veinlets cutting the ore. As the principal filling of mineralized veins it was noted at the Oneida, a prospect at the head of American Basin, where it carries sphalerite with a little pyrite, chalcopyrite, and galena, and at the Yellow Jacket claim on Bear Creek, on the northern edge of the quadrangle, where also it contains abundant sphalerite. In both cases the ore is too poor to work. As an important gangue constituent it was noted in some of the copper-bearing lodes north of Hanson Creek. At the Osceola claim in Cunningham Gulch it occurs pseudomorphous after tremolite. In the Camp Bird mine it is fairly abundant, filling vugs and spaces in the quartz left by comb structure. As a microscopic constituent calcite is found almost invariably in the wall rocks near the lodes, except where the rock has been silicified, in small amount with rhodonite and rhodochrosite in the so-called "pink spar" (chiefly rhodonite) of the Sunnyside and other mines, and with fluorite and quartz in a pale-green cryptocrystalline aggregate accompanying and forming part of the rich streak in the Camp Bird lode.

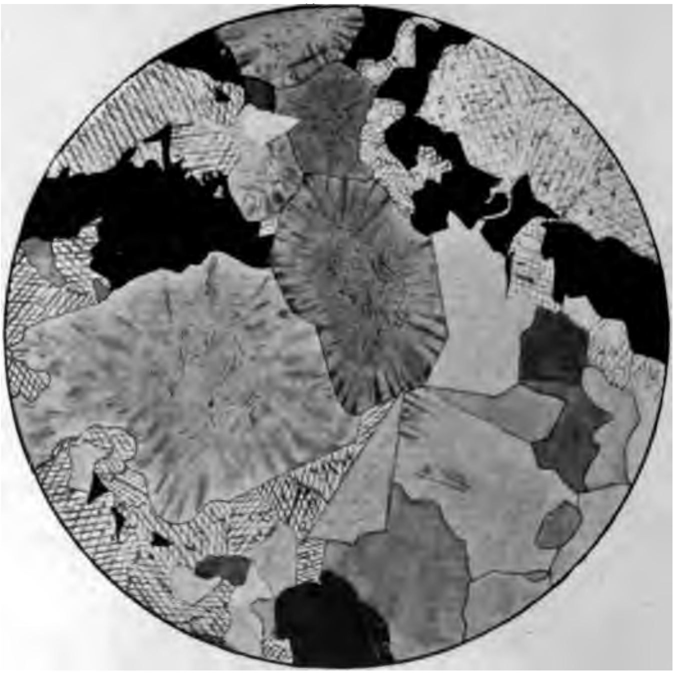
As limestone, impure massive calcite occurs at several points in the quadrangle, and on the east side of Sultan Mountain and at the Saratoga mine in Ironton Park is directly associated with deposits of ore.

Dolomite.—$CaMg(CO_3)_2$. Rhombohedral. Usually massive or in curved rhombohedra. Cleavage like calcite. White to brownish. Milky to opaque. Hardness, 3.5. Specific gravity, 2.88. Effervesces with cold dilute acid only when finely powdered.

This mineral is not abundant or important in connection with the *ore deposits*, but occurs as a microscopic constituent with rhodonite *and rhodochrosite*.



A. Finely crystalline ore from the Ridgway mine. Magnified 17 diameters; nicols crossed; large black areas, pyrite; small black areas, argentites, with a little sphalerite and galena; shaded areas, quartz.



B. Gangue of rich ore, Camp Bird mine. Magnified 17 diameters; nicols crossed; black areas, fluorite; shaded areas, quartz; cross-hatched areas, calcite.

VEIN-QUARTZ STRUCTURE.

Rhodochrosite.—$MnCO_3$. Rhombohedral. Massive or in small rhombohedra in vugs. Cleavage like calcite. Usually some shade of pink. Hardness, 3.5–4.5. Specific gravity, 3.5. Effervesces freely in powdered form with dilute acid.

Occurs abundantly in massive form as gangue in the Titusville lode, and in small amounts in the veins of the Empire group on Sultan Mountain, and in most of the lodes in the northeast quarter of the quadrangle, where it may usually be observed as minute rhombohedral crystals lining small vugs. In small quantity it always occurs in the veins containing rhodonite. In the Golden Fleece vein it forms, with quartz, the gangue of the rich free-gold ore, and also occurs in small amount in the Camp Bird lode. It is found in beautifully colored rhombohedral crystals in the Grizzly Bear mine on Bear Creek, just within the northern boundary of the quadrangle.

Kaolinite.—$K_4Al_2Si_2O_9$. Monoclinic. Massive, or in a loose powder consisting of microscopic crystalline scales. White. Hardness, 2–2.5. Specific gravity, 2.6. Can be scratched with the finger nail. Smooth to the touch.

This mineral occurs in very pure form in the National Belle mine as a snowy white powder, made up of minute crystalline scales. As seen in the upper workings in 1899 it occurs filling fissures in the country rock or as a filling between the fragments of brecciated zones near the ore bodies. It was apparently in these cases deposited later than the ores, partly taking the place in this mine of the clay gouge commonly associated with post-mineral movement in other localities.

As an original constituent accompanying the ores, kaolin occurs abundantly in the stock deposits of the Red Mountain district, as shown by the materials now visible on their dumps. This is usually a firm, compact variety, intimately associated with pyrite. A characteristic form is that in which the kaolin is traversed by numerous anastomosing veinlets of pyrite, giving it a spotted and sometimes a schistose appearance (fig. 6). It was not possible to investigate the occurrence of kaolin in any of the deeper workings of the Red Mountain mines, but from what could be seen it appears to have accompanied the ores to the greatest depths there attained—about 1,300 feet. It was evidently derived from the country rock adjacent to the ore bodies as a product of its alteration by the thermal waters.

In the Zuñi mine, on Anvil Mountain, compact kaolinite is abundant and is directly associated with pyrite, barite, and small nests of enargite to form the lower exposed portion of the ore body. The pyrite is often beautifully crystallized in very slightly modified octahedra, which are thickly embedded in the white kaolinite.

As a soft white powder kaolinite occurs with the gold quartz of the Tomboy and Camp Bird mines. In the Tomboy the kaolin is sometimes mixed with sericite.[1]

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[1] Purington, loc. cit., p. 840.

As an alteration product of the wall rock, more particularly of the feldspathic constituents, kaolinite is extremely common; but it is often impossible, without a chemical analysis, to distinguish it from sericite. Both minerals occur in similar fine aggregates, and they sometimes occur together. In such cases the microscope will not always serve to distinguish them.

Fluorite.—$CaFl_2$. Isometric. Massive, or in variously modified cubes and octahedra. Cleaves in four directions, forming octahedra. Colorless, or pale green or lilac. Hardness, 4. Specific gravity, 3.1.

Pale-green fluorspar is abundant on some of the dumps of the Aspen mine, but was not seen in place. In a massive condition it forms a vein which has been superficially prospected on the north side of Picayune Gulch, near its mouth, and was seen in a prospect near the Mountain Queen mine, in California Gulch, and in another prospect just east of Lake Como. It was also noted in the dump of the upper tunnel of the Micky Breen mine. Well crystallized with quartz, fluorite occurs in a prospect just north of the Old Lout mine, and in the Indiana tunnel in Grey Copper Gulch. In the Sunnyside lode, fluorspar, usually of a lilac tint, accompanies the best ore and is used by the miners as an indicator for free gold. Pale-green fluorite occurs *with calcite in the* quartz of the Tomboy lode and as a microscopic

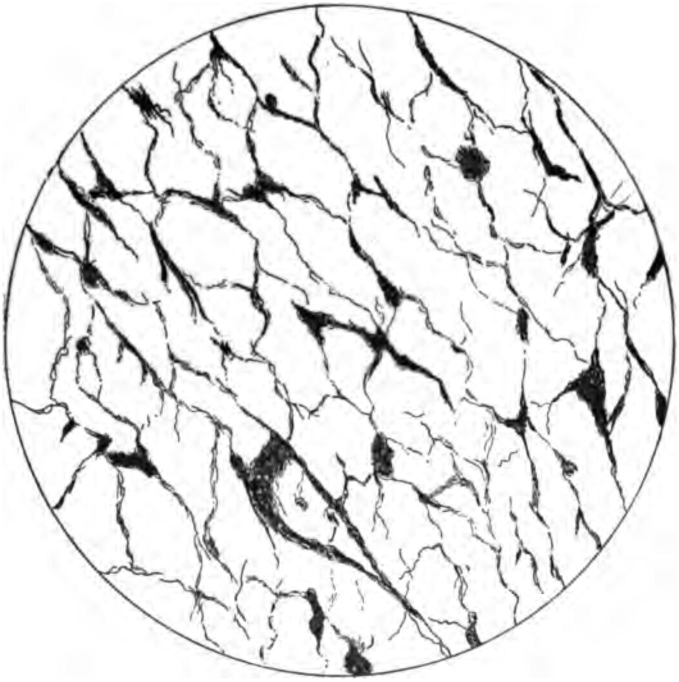

FIG. 6. Diagram illustrating common occurrence of kaolin in the Red Mountain region. The kaolin is traversed by a network of pyrite. From Zuñi mine. Natural scale.

constituent in some of the rich Camp Bird ore. It probably occurs also in visible masses in portions of the latter lode, although none was seen at the time of visiting the mine. It is abundant in the Morning vein of the Japan mine, and in the Empire-Victoria vein with hübnerite. This latter association, however, is much more strikingly shown on the Adams claim, near Gladstone, as described on page 256. On the whole, however, it is not a common gangue mineral in this quadrangle, and when not too abundant is frequently associated with free gold.

Rhodonite.—$MnSiO_3$. Triclinic. Occurs only in cryptocrystalline massive form in Silverton quadrangle. Color, rose pink, fading and then turning black on exposure to the weather. Hardness, 5.5–6.5. Specific gravity, 3.5.

The silicate of manganese, comprising much of the so-called "pink spar" of the miners, occurs in many of the larger lodes of the northeast quarter of the quadrangle as a fine-grained pink material, very hard and tough, forming partitions between the ore-bearing portions of the lodes, as elsewhere described. It is a conspicuous and abundant constituent in the Sunnyside lode, in the neighboring lodes in Placer Gulch, and on Treasure Mountain, particularly in the dominant northeast fissures, and occurs much less abundantly in other lodes of the northeast quadrant. It is also found in the Saratoga mine, near Ironton, where it has partly replaced limestone. It is often difficult to distinguish this mineral by inspection and ordinary physical tests from the pink carbonate of manganese, rhodochrosite, when both are massive. This is due to the fact that the rhodonite is seldom pure, but is associated with quartz, calcite, and rhodochrosite in grains or crystals of microscopic dimensions. The massive rhodonite, when powdered, often effervesces slightly with acids, due to this slight admixture of carbonates. The greater part of the pink powder remains insoluble in dilute, boiling hydrochloric acid, and this fact and an examination of thin sections under the microscope show that the so-called "pink spar" of the Sunnyside and neighboring mines is the manganese silicate, rhodonite.

Zunyite.—A very basic orthosilicate of aluminum. $(Al(OH,F,Cl)_2)_6Al_2Si_3O_{12}$. Isometric, tetrahedral. Colorless. Hardness, 7. Specific gravity, 2.8.

This mineral, which was first described and named by Hillebrand,[1] from the Zuñi mine, is limited in its occurrence, so far as known, to the Zuñi and to one or two adjacent prospects on Anvil Mountain. It occurs as small tetrahedral crystals up to 5 millimeters (three-sixteenths of an inch) in diameter, embedded in guitermanite or its oxidation product, lead sulphate, and associated with pyrite, enargite, bournonite, kaolin, and barite. The chemical composition of zunyite given by Hillebrand as the mean of eleven partial analyses is as follows:

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[1] On zunyite and guitermanite, two new minerals from Colorado: Proc. Colo. Sci. Soc., Vol. I, 1884, pp. 124-129. Also Bull. U. S. Geol. Survey No. 20, 1885.

Analysis of zunyite.

Constituent.	Per cent.	Constituent.	Per cent.
SiO_2	24.33	P_2O_5	.60
Fe_2O_3	.20	F	5.61
Al_2O_3	57.88	Cl	2.91
K_2O	.10		
Na_2O	.24		102.76
Li_2O	Trace.	Less O	3.02
H_2O	10.89		99.74

Although of much scientific interest, the mineral at present has no economic importance.

Other minerals.—Sericite, epidote, chlorite, and zircon occur in some of the ores, often merely as microscopic constituents. In the mines of Silver Lake Basin, chlorite, with the usual green color and minute radially foliated structure, occurs as nests in the vein quartz. The spots of chlorite are commonly regarded as an indication of good ore. It is abundant also in ore from the Silver King tunnel, on Mill Creek, and in vein quartz carrying pyrite in the Barstow mine. Sericite is often associated with kaolinite in ores formed by partial replacement of rhyolite and related potash-bearing rocks. A little chalcedony was noted in the Camp Bird ore. Alunite, although occurring in the National Belle mine and as an alteration product of some of the volcanic rocks of the Red Mountain range, has not been noted as a true gangue mineral. Gypsum occurs occasionally as small crystals in vugs of the Red Mountain ores.

In a fissure in the Silver Ledge mine there is a considerable quantity of a soft white material which, when moist, has a beautiful faint-green tint. When dry the substance is a snow-white powder, apparently of great purity. A partial analysis of this substance by Dr. Hillebrand gives the following approximate chemical composition:

Constituent.	Per cent.	Constituent.	Per cent.
SiO_2	14.83	Alkalies (largely K_2O)	.20
Al_2O_3 (with trace of Fe_2O_3)	39.42	CaO	0.68
H_2O	40.25	CO_2 (calculated for $CaCO_3$)	.53
SO_3	4.26		100.17

This may be calculated as a mixture of allophane, aluminite, gibbsite, alunite, and calcite, in the following proportions, by weight:

	Per cent.
Allophane (hydrous silicate of alumina)	58.0
Aluminite (hydrous sulphate of alumina)	15.5
Gibbsite (hydrate of alumina)	16.2
Alunite (hydrous sulphate of alumina and potash)	2.0
Calcite	1.2
	92.9

There remains over 5 per cent of superfluous water, which is not included in the foregoing calculation. The chemical analysis, however, does not pretend to be more than approximate, and the mineralogical composition deduced from it is of similar character.

ORE MINERALS.

Under this head are included minerals generally mined as ores, together with some compounds of the heavy metals not of commercial value in this region. Unless otherwise stated, these minerals are characterized by a metallic luster.

Pyrite.—Iron disulphide (FeS_2). Isometric, pyritohedral. Massive, granular, or in pentagonal dodecahedrons (pyritohedrons), octahedrons, or cubes, or in combinations of these forms. Pale-brass yellow. Hardness, 6. Specific gravity, 5.

The isometric sulphide of iron is common in all the ores of the district, and impregnates to a varying extent all of the country rock in the vicinity of the ore bodies. In some cases this impregnation has involved huge masses of rock, as in the Red Mountain range, which owes its color to the oxidation of the pyrite that is scattered in minute crystals throughout the altered andesites and other rocks which compose the range. Large bodies of pyrite, formed in part by replacement of country rock, are known to exist in the lower workings of many of the abandoned mines of the Red Mountain district. Other large masses of crumbling granular texture occur near Ironton, in the Saratoga and Baltic mines, in great part replacing limestone. Pyrite, in beautiful octahedra embedded in kaolin, is abundant in the Zuñi mine, on Anvil Mountain. As a rule the pyrite, when occurring in large bodies with little or no quartz, is not of sufficient value to pay for working. When, however, as in the Henrietta mine, it is associated with a considerable amount of chalcopyrite, it can sometimes be mined at a profit. Associated with true vein quartz, especially when the latter carries some free gold, the pyrite itself is usually sufficiently auriferous to repay treatment. In the Tomboy and Camp Bird mines the gold occurring in the pyrite is less in amount than that occurring free in the quartz. In the Gold King, however, the reverse is true. A large part of the gold in the Silver Lake mine is known to occur in pyrite.

Pyrite in radially fibrous spherules, and at first supposed to be the orthorhombic sulphide of iron, marcasite, was noted in the dumps of the Red Cloud and Old Lout mines, and also occurred as small stalactites in cavities in the Genesee-Vanderbilt ore body. It was noted in radial spherules embedded in calcite at the Yellow Jacket claim on Bear Creek, near the northern edge of the quadrangle. Dr. H. N. Stokes, in the course of a chemical investigation on the iron sulphides, has shown that the foregoing radial forms are not marcasite but common pyrite. Dr. Stokes has kindly furnished the following note in regard to his method of determination:

Supposed marcasite from the Red Cloud mine, Colorado.—Carefully selected portions of the mineral, as free as possible from foreign substances, gave the "oxidation number" 65, that of pyrite being 60, and of marcasite 17. There can be no question, therefore, that the substance is pyrite, the excess of 5 over the normal figure being accounted for by small quantities of As, Pb, and Cu, which were found on analysis, the effect of these being to raise the "oxidation number."

The "oxidation number" may be thus defined: When a sulphide is boiled with a solution containing 1 gram ferric iron per liter, Fe''' is reduced to Fe'', and iron, if present in the mineral, goes into solution. At the same time more or less S is oxidized to SO_3. In the case of FeS_2 this is expressed by

$$\frac{0.333\,b}{a}-25=\text{per cent of sulphur oxidized}=\begin{cases}60 \text{ for pyrite}\\17 \text{ for marcasite}\end{cases}$$

where a=amount of iron dissolved,
b=amount of Fe'' produced by reduction.

When other sulphides are present the effect is to contribute to b but not to a, thus increasing the apparent percentage of sulphur oxidized, as in the present case.

Tetrahedrite (*gray copper*).—Sulphantimonite and sulpharsenite of copper. The composition of tetrahedrite proper is $4Cu_2SSb_2S_3$, corresponding to 52.1 per cent of copper. For tennantite, the arsenical variety, it is $4Cu_2SAs_2S_3$, corresponding to 57.5 per cent of copper. These two varieties are connected by various intermediate compounds. Isometric, tetrahedral; commonly massive. Color, gray. Streak, brownish or reddish. Hardness, 3–4.5. Specific gravity, 4.4–5.1.

This mineral rivals galena in this region in importance and abundance as an ore constituent. Its high percentage of copper, with the fact that it often carries a large amount of silver replacing part of the copper, gives it its value. Most of the varieties seen contain both arsenic and antimony, but the latter predominates, especially in the highly argentiferous varieties sometimes known as freibergite (the typical freibergite from Freiberg contains over 30 per cent of silver), which is usually of a lighter gray than ordinary tetrahedrite. Moderately argentiferous tetrahedrite occurs in the North Star, Belcher, Empire, Little Dora, and other lodes on Sultan Mountain, in the Aspen mine on Hazelton Mountain, and in the Royal Tiger and other mines in Silver Lake Basin, associated with galena, chalcopyrite, sphalerite, pyrite, quartz, and barite. An antimonial variety rich in silver, probably to be referred to freibergite, constituted the principal ore of the North Star (King Solomon) mine. Tetrahedrite has been found in the Pride of the West, Philadelphia, and Highland Mary mines, in Cunningham Gulch, and usually constituted the richest ore. It occurs in most of the lodes of Picayune and California gulches, in the Tom Moore lode, in the Mickey Breen, Poughkeepsie, Bonanza, and other mines in Poughkeepsie Gulch, and in many other mines and prospects in various parts of the quadrangle. In some, such as the North Star (King Solomon), Tom Moore, and Mickey Breen, it is the principal constituent of ore bodies of some size and continuity, but in others, especially in those lodes carrying much galena, the tetrahedrite often occurs as bunches in the other ore. A little lead may sometimes replace part of the copper, as was found to be the case with a tetrahedrite carrying both arsenic and antimony, from the Black Diamond claim, on California Mountain. Tetrahedrite was present also in the ores of the Yankee Girl, Silver Bell, and other Red Mountain mines.

Enargite.—Sulpharsenate of copper ($3Cu_2S.As_2S_5$). Contains 48.3 per cent of copper. Orthorhombic. One perfect cleavage. Grayish black to iron black. Hardness, 3. Brittle. Specific gravity, 4.4.

Enargite is of somewhat frequent occurrence in the ores of the Red Mountain range. It was found abundantly in the Zuñi and Congress mines, and formed the principal ore of the National Belle. Handsome clusters of prismatic crystals incrusted with malachite and quartz were seen from the now inaccessible workings of this mine. According to Mr. Emmons, enargite occurred in the Yankee Girl.

The enargite of the Zuñi mine is said to have carried over 200 ounces of silver per ton. In the National Belle it was probably of much lower grade.

Chalcocite.—Cuprous sulphide (Cu_2S), corresponding to 79.8 per cent of copper. Orthorhombic, commonly massive. Blackish lead-gray. Hardness, 2.5–3. Specific gravity, 5.5–5.8.

Stromeyerite.—Sulphide of silver and copper ($(AgCu_2)S$). Form and physical properties like chalcocite, except slightly higher specific gravity—6.1–6.3.

These two closely related species do not always admit of sharp distinction. Stromeyerite may be regarded as chalcocite in which about half of the copper is replaced by silver. Chalcocite is itself a valuable ore mineral on account of its high percentage of copper, but stromeyerite, which may contain over 50 per cent of silver, is particularly valuable. The two minerals are probably connected by intermediate varieties.

Chalcocite, more or less argentiferous, was noted on the dump of the Frank Hough mine, and bornite in the Silver Link and John J. Crooke. Stromeyerite is reported to have been formerly an abundant ore in the Yankee Girl and Guston mines, where it occurred above a depth of 600 feet, between galena above and bornite below. One lot of 6 tons of this rich ore from the Yankee Girl contained over 5,390 ounces of silver per ton,[1] while one small lot from the sixth level of the Guston is stated to have contained 15,000 ounces of silver per ton, which corresponds roughly to the percentage of silver in pure stromeyerite. None of this ore could be seen in 1899 or 1900.

Some of the richest ore in the New York City lode, in the Silver Lake mine, contains small quantities of a black amorphous substance, associated with chalcopyrite and pyrite. It was at first supposed to be black oxide of copper, but upon closer investigation proves to be a copper sulphide, probably chalcocite.

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[1] Schwarz: Trans. Am. Inst. Min. Eng., Vol. XVIII, 1889-90, p. 145.

Bornite.—Sulphide of copper and iron ($3Cu_2S.Fe_2S_3$). Contains 55.5 per cent of copper. Isometric. Commonly massive. Copper red or pinchbeck brown on fresh fracture, but soon becomes iridescent from tarnish, whence the name "peacock ore." Hardness, 3. Brittle. Specific gravity, 4.9–5.4.

This mineral, often highly argentiferous by the replacement of a portion of the copper by silver, was a very important constituent of the large ore bodies formerly worked in the Red Mountain district. According to T. E. Schwarz, it was the "principal ore for large masses"[1] in the Yankee Girl. It formed large solid masses in the Guston mine, associated with barite, the crystals of the latter being often embedded in the bornite. It also occurred in the Genesee-Vanderbilt mine. It is usually intimately associated with chalcocite and chalcopyrite. With quartz it occurs in bunches in the Silver Link mine and also in the John J. Crooke, a prospect north of Hensen Creek, associated with chalcocite.

Chalcopyrite (*yellow copper*).—Sulphide of copper and iron ($Cu_2S.Fe_2S_3$), corresponding to 34.5 per cent of copper. Tetragonal, sphenoidal. Commonly massive. Brass yellow. Hardness, 3.5–4. Brittle. Specific gravity, 4.1–4.3.

This is a common ore mineral throughout the quadrangle, and is sometimes auriferous, as in the Sound Democrat, or argentiferous (carrying also a little gold), as in the Yankee Girl, Guston, National Belle, and other Red Mountain mines, and in the Guadaloupe mine on Abrams Mountain. It is very abundant in the Titusville mine, in the New York City lode of the Silver Lake mine, and in the Hamlet mine. Associated with pyrite, it forms the ore of the Henrietta mine, and with tetrahedrite much of the ore of the Tom Moore lode. It is always present in ores carrying galena, sphalerite, and pyrite, although the amount varies widely in different occurrences. In the Saratoga mine it occurs with pyrite and galena, replacing limestone.

Galena.—Lead sulphide (PbS). Isometric. Rarely showing external crystal form, but characterized by its perfect cubic cleavage. Lead gray. Hardness, 2.5. Specific gravity, 7.5.

This very important ore mineral, which when pure contains 86.6 per cent of lead, occurs in nearly every ore deposit in the quadrangle, although in extremely varying amounts. In the lodes of the Silver Lake Basin and vicinity it occurs in coarsely crystalline masses, associated with quartz, sphalerite, chalcopyrite, pyrite, and sometimes barite and tetrahedrite. Such coarsely crystalline varieties carry in this region relatively low silver values. In other lodes, in Maggie, Picayune, and Placer gulches, and around Mineral Point, the galena sometimes occurs so minutely crystallized as to give merely a dark color to the quartz in which it is inclosed. This finely crystalline galena is often, but not invariably, highly argentiferous, as in the Sound Democrat mine in Placer Gulch. In the Sunnyside mine the foreman, J. James, informed me that he had seen free gold embedded in galena.

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[1] Personal letter.

Sphalerite (*zinc blende*).—Zinc sulphide (ZnS). Isometric, massive, and tetrahedral. In variously modified tetrahedral forms. Perfect dodecahedral cleavage. Luster resinous. Color, various shades of yellow or orange to dark brown or black. Hardness, 3.3 to 4. Specific gravity, 4.0.

This is a very common mineral in this region and always accompanies galena. It is not, however, worked as an ore of zinc, and its presence in the ore often involves additional cost in concentrating and smelting. The light-yellow varieties, commonly termed "rosin zinc" by the miners, are often associated with the occurrence of gold. An orange or red sphalerite is common in the ores of the Red Mountain range. In the Yellow Jacket, a prospect on Bear Creek near the northern edge of the quadrangle, sphalerite occurs abundantly in a peculiar form, viz, as cylindrical aggregates of radial structure, thickly embedded in a gangue of calcite. These aggregates, which occur in all sizes up to an inch or so in diameter, frequently contain small specks of galena and chalcopyrite. Spherules of marcasite also occur occasionally embedded, like the sphalerite, in the calcite. When the calcite is dissolved in acid the sphalerite remains as a loose mass of cylindrical rods lying in all directions. In nearly all cases these rods are broken sections, as if they originally formed a loose mass of small shattered stalactites which were subsequently cemented by calcite.

Bournonite.—Sulphantimonite of lead and copper ($3(PbCu_2)S.Sb_2S_3$). Orthorhombic. Steel gray, lead gray, or black. Hardness, 2.5 to 3. Rather brittle. Specific gravity, 5.8.

According to Mr. S. F. Emmons's unpublished notes, this mineral is reported as having been found in the Yankee Girl mine. A lead-copper sulphantimonarsenite, probably bournonite with some arsenic replacing the antimony, occurs at the Zuñi mine, in small vertically striated prisms with pyrite and zunyite.

Zinkenite.—Sulphantimonite of lead ($PbS.Sb_2S_3$). Orthorhombic, but occurs chiefly massive. Steel gray. Hardness, 3 to 3.5. Specific gravity, 5.3.

Described and analyzed by Hillebrand[1] from the Brobdignag claim, where it is said to occur sparingly with barite. None could be seen in 1899 or 1900.

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[1] Mineralogical notes: Proc. Colo. Sci. Soc., Vol. I, 1884, pp. 121-123.

Guitermanite.—Sulpharsenite of lead ($3PbS.As_2S_3$). Massive, compact. Bluish gray. Hardness, 3. Specific gravity, 5.9.

This mineral, with zunyite, was first described and named by Dr. Hillebrand[1], and occurs, as far as known, only in the Zuñi and adjacent claims. It always incloses the minute, sparkling tetrahedrons of zunyite, and is intimately associated with pyrite, enargite, kaolin, and barite. It alters superficially to anglesite. As it contains about 66 per cent of lead, and probably some silver, it is a valuable ore.

Stibnite.—Antimony sulphide (Sb_2S_3). Orthorhombic. Usually in clusters of radiating prisms. Perfect cleavage in one direction. Lead gray. Hardness, 2. Specific gravity, 4.5.

A single specimen of this mineral was seen, which was stated on reliable authority to have come from the North Star mine on Sultan Mountain. It is readily distinguished by its lustrous cleavage surfaces and softness, being easily scratched with the finger nail.

Polybasite.—Sulphantimonite of silver ($9AgS.Sb_2S_3$), with part of silver replaced by copper and part of antimony by arsenic. Orthorhombic. In characteristic, short, six-sided tabular prisms, with triangular striations and beveled edges. Iron-black. Hardness, 2 to 3. Specific gravity, 6.1.

This rich silver ore is known to have occurred in the upper workings of the Yankee Girl, and probably in other mines of the Red Mountain district. Well-crystallized specimens from this region are preserved in the museum of the Bureau of Mines, Denver, and in various private cabinets.

Proustite (*ruby silver*).—Sulpharsenite of silver ($3Ag_2S.As_2S$), corresponding to 65.4 per cent of silver. Rhombohedral, hemimorphic. Luster, adamantine. Transparent to translucent. Color, scarlet-vermilion, but somewhat masked by brilliant luster. Hardness, 2.25. Brittle. Specific gravity, 5.5 to 5.6.

Few of the ores now mined show this mineral, although it was seen in the Ben Butler mine, associated with galena and perhaps argentite. It is also known in the Ridgeway mine and has been reported on good authority from the Red Cloud, Polar Star, Mammoth, Annie Wood, Palmetto, and Wheel of Fortune mines. It is known to have occurred in the Yankee Girl, and a specimen was seen which was said to have come from the Genesee-Vanderbilt mine. It characterizes the upper portions of argentiferous ore bodies and is not known at depths over a few hundred feet.

Bismuthinite.—Sulphide of bismuth (Bi_2S_3). Orthorhombic. One perfect cleavage. Lead-gray. Hardness, 2. Somewhat sectile. Specific gravity, 6.5.

This sulphide of bismuth occurs in slender prismatic crystals, with specularite in quartz at the Neigold claim on the south slope of Galena Mountain.

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[1] *On zunyite and guitermanite, two new minerals from Colorado*: Proc. Colo. Sci. Soc., Vol. I, *1884, pp. 129-131.* Also Bull. U. S. Geol. Survey No. 20, 1885.

Argentite.—Silver sulphide (Ag_2S), containing 87.1 per cent of silver. Isometric. Blackish lead-gray. Hardness, 2 to 2.5. Sectile. Specific gravity, 7.3.

This valuable ore of silver, which is readily distinguished by the ease with which it can be cut with a knife without breaking or splintering, is not abundant in the Silverton quadrangle. It was distinctly recognized only at the Ridgway mine, where, curiously enough, it is called "brittle silver." Here it constitutes the richest ore, and is evidently one of the most recently formed of all the ore minerals, as it occurs characteristically in vugs, incrusting or filling the interstices between the quartz crystals. It probably occurs also in the Gold Nugget and other prospects in Maggie Gulch, and is said to have constituted a large part of the rich ore formerly extracted from the Polar Star mine, on Engineer Mountain, and from the Palmetto mine, in American Flats.

Molybdenite.—Molybdenum disulphide (MoS_2). Probably hexagonal. Occurs in scales, with eminent basal cleavage, or compact. Laminæ flexible, but not elastic. Lead-gray. Leaves a bluish-gray mark on paper. Feel, greasy. Hardness, 1 to 1.5.

This mineral occurs in the Sunnyside Extension mine, where it has been mistaken for graphite. Here it frequently contains free gold. It has not been recognized elsewhere within the quadrangle.

Hematite (*specularite*).—Ferric oxide (Fe_2O_3). Rhombohedral. Lamellar or in thin scales. Color, steel-gray or iron-black. Streak, cherry-red or reddish-brown. Hardness, 5.5–6.5, but often apparently much softer on account of its scaly structure. Specific gravity, 5.2.

The variety of hematite known as specular iron is frequently met with in small quantities in the lodes of the Silverton quadrangle. It occurs, for example, in the Crown Point lode on Silverton Mountain, in the Little Giant lode (on the dump), in the Neigold claims on Galena Mountain, and in the Daniel Webster prospect in Maggie Gulch. In all cases observed it is a vein mineral inclosed in quartz. It is of no economic importance, but is frequently mistaken for more valuable minerals—in one case for "brittle silver." It is easily recognized by its scaly structure, brittleness, and red color when crushed.

Sulphobismuthites.—These include cosalite ($2PbS.Bi_2S_3$), galenobismuthite ($PbS.Bi_2S_3$), alaskaite ($(PbAg_2)S.Bi_2S_3$), beegerite ($6PbS.Bi_2S_3$), kobellite ($2PbS.(Bi,Sb)_2S_3$), and possibly other species.

Sulphobismuthites of lead, carrying usually considerable silver and sometimes a little copper, are of frequent occurrence, particularly in the northern half of the quadrangle. As most of the above-named minerals resemble one another very closely in physical properties and as a rule occur massive, their specific identification is impossible without a quantitative chemical analysis in each case. Nor is this method often available, for the association of these sulphobismuthites with other ore minerals is usually such that pure material suitable for chemical analysis can not be obtained. They are nearly all lead-gray in color, with hardness varying from 2.5 to 4.

The argentiferous galenobismuthite named by Koenig[1] *alaskaite* occurs abundantly in the Alaska mine and in the Acapulco claim adjoining it on the east. Its occurrence and accompanying minerals are described on page 195.

Cosalite, from the Yankee Girl mine, with more or less of the lead replaced by silver, has been analyzed by Low,[2] and probably occurs in other mines of the vicinity. It has been reported also from the Alaska mine. Kobellite has been analyzed and described by Keller[3] from the Silver Bell mine, and beegerite, from Poughkeepsie Gulch, by Koenig.[4] The naming and identification of these species from the Silverton quadrangle rests upon chemical analysis of massive, more or less impure material, and these results have not yet been confirmed by any investigation of crystal form.

In the course of the present investigation sulphobismuthites have been met with in many of the ores, but never with external crystal form nor in such amount or purity as would warrant complete chemical analysis, whereby alone they can be specifically determined.

At the Barstow mine the richest ore is a bright lead-gray mineral, of hardness 3 to 3.5 and specific gravity 7.04 at 30° C. (Hillebrand). It shows indistinct crystal forms, suggestive of isometric symmetry, and is very intimately intergrown with pyrite.

The purest material that could be picked out proved to be a mixture of a lead sulphobismuthite with pyrite and a telluride. According to Dr. Hillebrand the following may be taken as a rough approximation to the chemical composition of this mixture:

Approximate chemical composition of material from Barstow mine.

Constituent.	Per cent.	Constituent.	Per cent
Pb	45.5	Fe	2.8
Bi	22.5	Te	3.5
Ag	6.0	S	14.1
Au	.08	Insol	1.5-2.0
Cu	.3		

Had pyrite been the only mineral present with the sulphobismuthite it might have been easily deducted from the completed analysis. But the presence of tellurium shows that there is present also some telluride of unknown composition which can not be thus allowed for. The idea of a quantitative analysis was therefore abandoned. The above rough approximation indicates the probable presence of a mineral of the composition of beegerite, mixed with pyrite and perhaps an auriferous hessite (telluride of silver).

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[1] Proc. Am. Philos. Soc., Vol. XIX, 1881, pp. 472-477.

[2] *Proc. Colo. Sci. Soc.*, Vol. I, 1883-84, p. 111.

[3] Zeitschr. für Kryst., Vol. XVII, 1890, pp. 67-72.

[4] Loc. cit.

In the Sunnyside Extension mine a sulphobismuthite of lead and silver, showing no distinct crystal form, occurs intimately associated with molybdenite and free gold in an ore containing quartz, barite, sphalerite, pyrite, and galena. In the Mastodon, which adjoins the Sunnyside Extension on the north, an argentiferous sulphobismuthite of lead showing indistinct prismatic crystallization occurs so finely disseminated in quartz as to give the latter a dark clouded appearance.

In the Custer claim on California Mountain an argentiferous lead, sulphobismuthite, forms the richest ore, and similar bismuthiferous compounds occur in the ores of the Sound Democrat and Silver Queen mines in Placer Gulch.

A lead-copper sulphobismuthite, probably argentiferous, occurs in small, ragged prisms, frequently forming star-like radial clusters, in quartz with pyrite at the Uncompahgre Chief, near Mineral Point.

At the Silver Bell mine, between Ironton and Red Mountain, the richest ore was a massive argentiferous lead sulphobismuthite carrying up to 1,000 ounces of silver per ton. Massive argentiferous lead sulphobismuthites, of probably more than one species (one of them cupriferous), occurred in the Genesee-Vanderbilt ores, intimately associated with barite and pyrite. A massive lead sulphobismuthite (with, perhaps, a little copper) has been found in the Silver Queen mine on Bear Creek. In the Neigold group of claims on Galena Mountain a lead sulphobismuthite, carrying a little silver and perhaps some copper, occurs as small indistinct prisms and specks in quartz with pyrite, specularite, and bismuthite. Lastly, it is known that rich bismuthiferous ores, probably argentiferous lead sulphobismuthites, were formerly mined in the Old Lout and Poughkeepsie mines, and are probably present in varying amounts in most of the lodes of Poughkeepsie Gulch.

Tellurides.—The occurrence of tellurides of gold or silver has been noted at only four localities within the quadrangle, and at each of these in small amounts only. In some of the rich ore of the Camp Bird mine a little tellurium, probably occurring as a telluride, has been detected chemically by Dr. Hillebrand, although no tellurium mineral has been recognized. In the Barstow mine small amounts of an unknown telluride are intimately associated with an argentiferous lead sulphobismuthite and pyrite. Its presence can be detected only by chemical means. At the Silver Ledge mine a small amount of a telluride resembling calaverite was found, with free gold in a single small pocket. At the Magnet mine telluride of silver, probably hessite, occurs, intimately associated with argentiferous galena and a little free gold in a quartz gangue.

Gold.—Isometric, but rarely showing crystal form. Usually in irregular hackly particles. Gold yellow. Hardness, 2.5–3. Very malleable and ductile. Specific gravity, 15.6–19.3.

Free or native gold occurs in arborescent sheets in quartz and rhodonite in the Golden Fleece vein (see p. 183). In the Sunnyside

Extension mine it has been found, scattered through masses of spongy quartz, as implanted crystals on the faces of quartz crystals in vugs, and embedded in yellow sphalerite and molybdenite. It is also sometimes present in the ores of the Sound Democrat and Silver Queen mines of Placer Gulch. In the Sunnyside mine it occurs intimately associated with quartz, rhodonite, fluorite, yellow sphalerite, and galena, and has been found embedded in the latter. In the Camp Bird it is inclosed as small particles with galena, sphalerite, pyrite, chalcopyrite, and traces of some telluride, in quartz and fluorite (see p. 90). In the Tomboy it is found with pyrite in quartz, but only rarely in visible particles. Visible particles are also met with in bunches in the quartz in the Gold King mine. In the mines of the Silver Lake Basin free gold is very rarely seen, and only one specimen has been noted in the Royal Tiger.

One small bunch of free gold, associated with a telluride (probably calaverite), has been found in the Silver Ledge mine. Rich pockets of free gold are reported to have been mined in early days in the Whale and Argentina lodes in Savage Basin, and it was the free gold of the Little Giant in Arrastra Gulch which in the early seventies first called attention to the San Juan region.

Silver.—Isometric. Commonly filiform (wire silver). Silver white, but sometimes black through tarnish. Hardness, 2.5–3. Ductile and malleable. Specific gravity, 10.1–11.1.

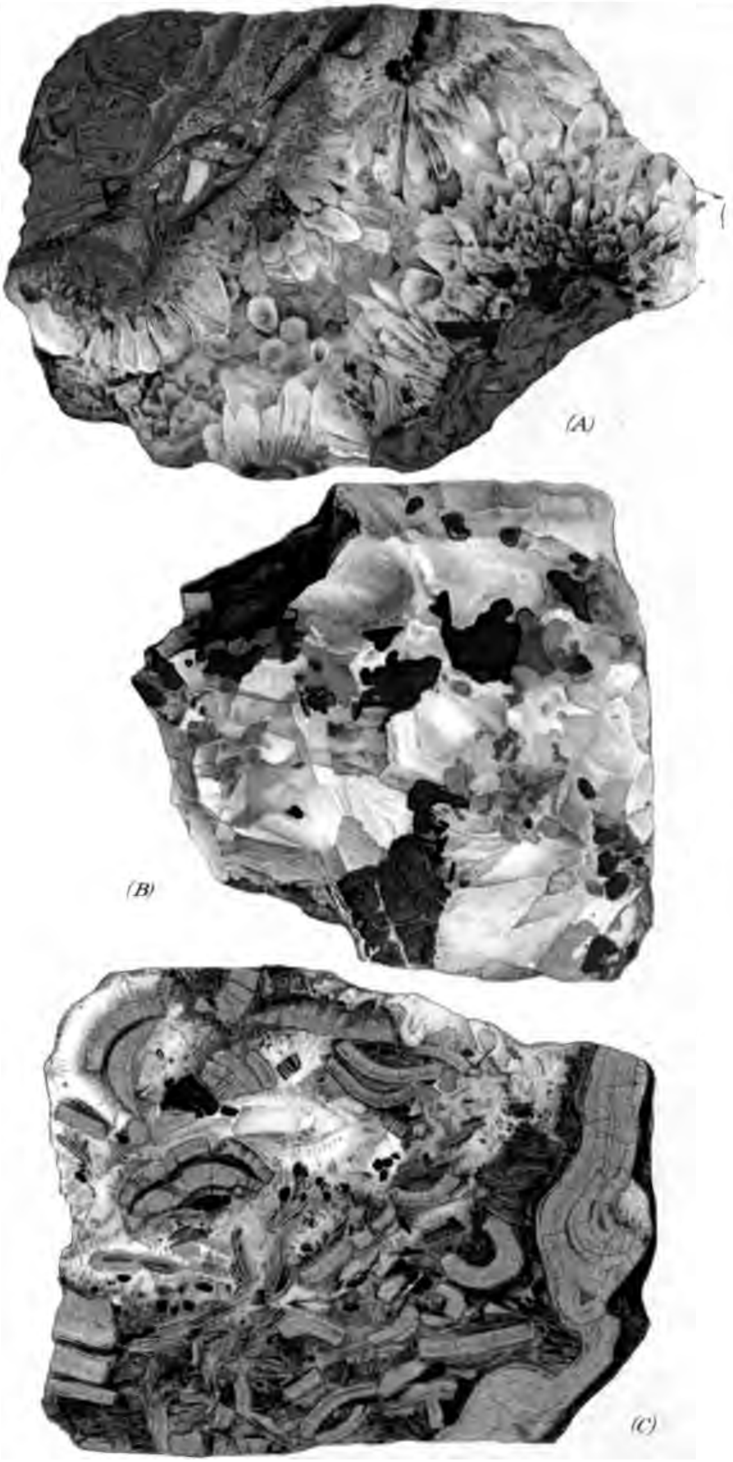
Native silver is very rarely seen in the ores worked at the present day. But in the form of wire silver it was formerly found in the Pride of the West, Aspen, Ben Franklin, and Sunnyside Extension mines. It occurs occasionally in the Aspen and in the Antiperiodic mines, and, as small hackly particles and plates solidly embedded in limestone (probably Devonian), on the Fairview claim on Sultan Mountain. It is probably in all cases of secondary origin, resulting from the oxidation of other silver minerals.

Copper.—Isometric. Occurs in irregular plates and branching forms. Copper red. Ductile and malleable. Hardness, 2.5–3. Specific gravity, 8.8–8.9.

Occurs in small amounts in the Royal Tiger, Tom Moore, and Sunnyside Extension mines. It is confined, as far as known, to the superficial portions of the lodes and is of later formation than the bulk of the ore. In the Tom Moore it occurs in a stringer of quartz which contains small crystals of hübnerite and cuts the ore.

Hübnerite.—Tungstate of manganese ($MnWO_4$), usually with some iron. Monoclinic. One perfect cleavage. Usually in bladed prisms; often radial. Brownish red to black. Luster, submetallic or metallic-adamantine. Hardness, 5–5.5.

This mineral occurs rather widely distributed over the Silverton quadrangle as a vein mineral associated with quartz and fluorite. It is most abundant at the Adams lode on Bonita Mountain, where it forms striking radial clusters of brownish-red crystals embedded in



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quartz and pale-green fluorite. It is also found in a quartz lode in Dry Gulch, but in smaller crystals. In the Tom Moore lode it was noted as minute brown prisms in quartz. On Sultan Mountain it has been obtained from the North Star mine, and occurs in moderate abundance in the Empire-Victoria lode. The mineral from the last-named locality is nearly black and probably contains considerable iron, thus approaching wolframite in composition. It is embedded in quartz and pale-green fluorite.

This mineral, if found in sufficient quantites, would be valuable as an ore of tungsten. It is doubtful, however, whether any of the above-mentioned deposits contain it in sufficient abundance to render possible its commercial extraction.

PRODUCTS OF SUPERFICIAL DECOMPOSITION.

Owing to the vigorous erosion to which the Silverton region has been subjected, oxidized ores have seldom had opportunity to accumulate to any great depth, and play a small part in mining operations. Small amounts of the carbonates of copper, malachite, and azurite, and the carbonate of lead, cerussite, can be found in the croppings of most of the lodes, and cerussite was mined to some extent from the upper levels of the Silver Lake mine. Anglesite, or sulphate of lead, also occurred near the surface in the Silver Lake and Whale lodes and formed an important part of the ore body of the Zuñi mine, where it resulted from the oxidation of guitermanite. Anglesite, resulting from the oxidation of galena and often containing kernels of the sulphide, occurs in the Anaconda mine about three-fourths of a mile south of Cinnamon Pass, whence four or five carloads, carrying 55 per cent of lead and 14 to 18 ounces of silver per ton, have been shipped. In the Saratoga mine the greater part of the ore has been mined comparatively near the surface, and consisted of a soft mass of ferruginous clay carrying carbonate of lead and silver, probably native or as chloride.

Under some circumstances partial oxidation has extended to depths of several hundred feet. In the Silver Lake mine more or less oxidation has taken place where the lodes of Group II join the Silver Lake lode. Subsequent movements have allowed surface waters to descend at the intersections of the planes of weakness determined by the lodes. The partial oxidation of the Tomboy and Camp Bird lodes at considerable depth, and the deposition within them of black oxide of manganese, are apparently due to fracturing of the original lode filling, thus allowing the downward seepage of oxidizing waters.

STRUCTURE OF THE LODE ORES.

MEGASCOPICAL STRUCTURES.

Six kinds of ore structure have been recognized in the lode ores of the Silverton quadrangle:

1. *Massive structure.*—The quartz, galena, sphalerite, chalcopyrite,

pyrite, and other minerals are all crystallized irregularly in the fissures without external crystal form and without definite arrangement. As a rule the constituent minerals appear to have crystallized practically simultaneously.

This structure is exceedingly common and is the characteristic one of the quadrangle. It is typically exhibited by the ores of the Silver Lake, Royal, Stelzner, New York City, Iowa, and East Iowa lodes of the Silver Lake Basin (Pl. XI, *B*). The quartz sometimes incloses empty spaces, either as minute interstices between interlocking quartz prisms or as small vugs lined with quartz crystals. Occasionally, instead of being perfectly massive, the ore exhibits indistinct traces of the structure next to be described. The two are connected by intermediate forms.

2. *Banded structure by deposition.*—The ore and gangue minerals have been deposited in more or less parallel sheets, distinguishable from each other by the fact that they contain the constituent vein-forming minerals in different proportions.

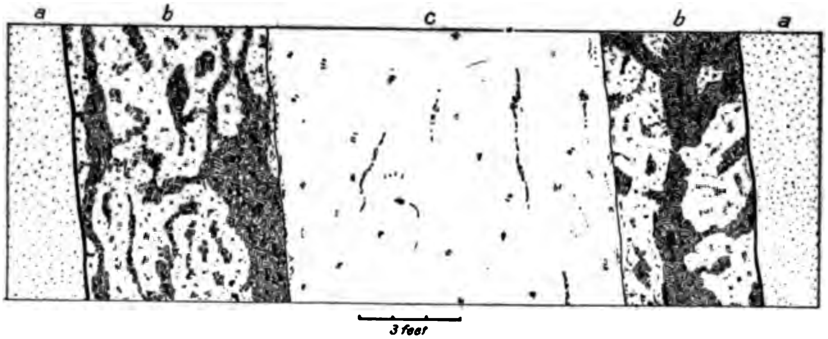
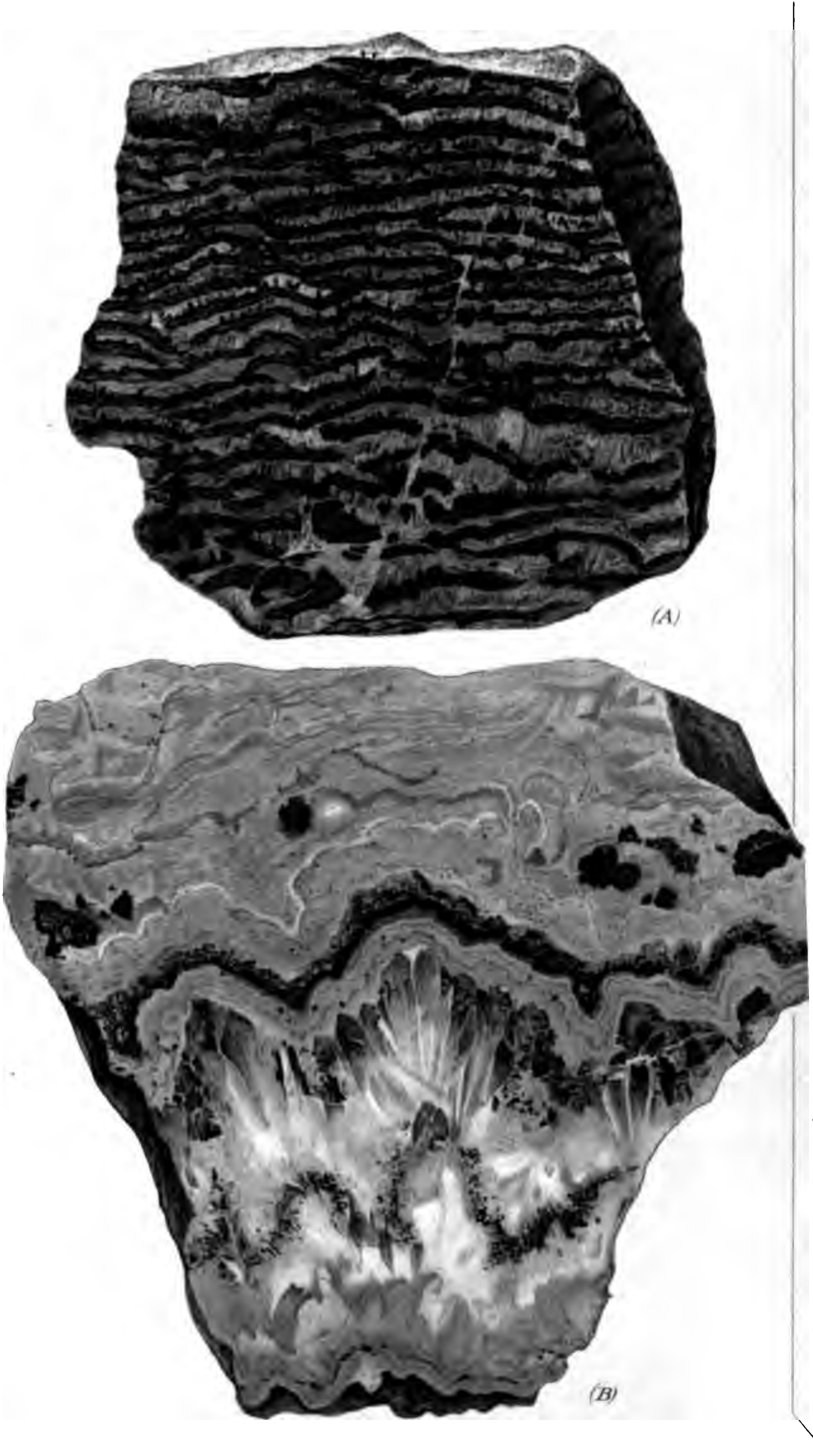


FIG. 7.—Cross section of No-Name lode, Sunnyside mine. *a*, country rock; *b*, ore, chiefly galena with quartz gangue; *c*, rhodonite.

This is far less common than the preceding, but it is found in many small and unproductive veins and in some of the more important lodes, such as the Gold King, where the pyrite has been deposited in bands alternating with white quartz. On the large scale it is perhaps exemplified in the Sunnyside lode, where the ore streaks, themselves of massive structure, consisting of galena, sphalerite, chalcopyrite, pyrite, tetrahedrite, and free gold in a gangue of quartz, rhodonite, and a little fluorite, are separated by plates or lenses of relatively barren rhodonite. This structure is illustrated by fig. 7, which is a section of the No-Name vein in the Sunnyside ground.

In the smaller veins and stringers carrying galena and quartz the galena frequently fills the medial suture formed by the opposing pyramidal ends of the quartz crystals which have grown out from the walls of the fissure. This is well seen in some of the veinlets of the *Silver Lake* Basin. Even the larger lodes, with prevailingly massive



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ORE-STRUCTURES

structure, not infrequently reveal a tendency toward a final crystallization of the galena in the middle portion of the vein, as may be seen in parts of the Iowa lode and in the Idaho claim, on the Titusville lode. This same tendency is also illustrated in fig. 8, which is a sketch of a small regularly banded vein prospected by the roadside half a mile north of Houghton Mountain and close to the London shaft.

Remarkably fine and regular banding was observed in the ore thrown out on the dump of a small deserted tunnel on what is probably the Osceola claim, in Cunningham Gulch, about half a mile above Stony Gulch. In its most perfect form this banding consists of dark sheets of finely crystalline sphalerite and galena about one-half millimeter in thickness, separated by plates of vitreous quartz about 2 millimeters in thickness. The result is a remarkably regular and striking fine banding (Pl. XII, *A*). The little sheets of quartz frequently show comb structure and have apparently crystallized in open spaces. In some facies with rather wider banding chalcopyrite occurs, chiefly in the quartzose bands. The cause of such fine and regular banding is not known, but is probably connected with metasomatic replacement. The ore is apparently of too low grade for profitable working and was not seen in place.

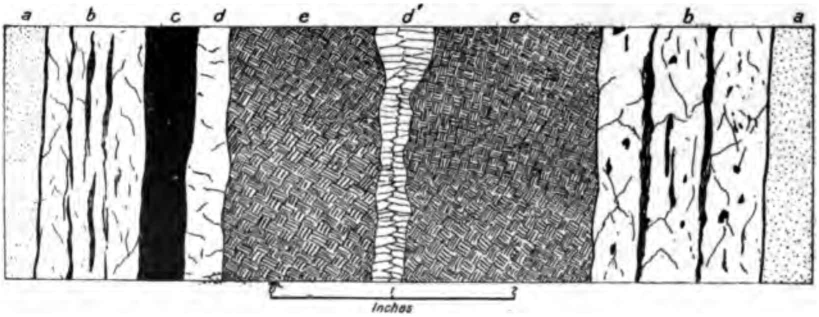

FIG. 8.—Cross section of banded vein near the London shaft, Mineral Point. *a*, country rock; *b*, quartz and chalcopyrite; *c*, tetrahedrite; *d*, *d'*, quartz; *e*, galena.

Another form of original banding is that exhibited by the rich gold ore of the Camp Bird mine (Pl. XII, *B*). As elsewhere described, the rich portion of this lode is a sheeted zone in San Juan andesitic breccia and lies next the main hanging wall of the lode. Within the individual fissures of this zone the quartz has crystallized freely in open spaces. Thus, in the specimen illustrated, which represents a characteristic cross section of one of the richest ore streaks, the quartz crystals are implanted at their bases on a thin seam of chalcedony and carbonates carrying a little finely divided galena and sphalerite and associated with pulverulent white kaolin. The thickness of this seam of chalcedony and kaolin varies from 1 to 2 centimeters. From this as a foundation the quartz crystals grew out into the fissure. But after they had attained a length of 2 or 3 centimeters there was an enrichment of the depositing solutions, as is shown by an undulating dark band traversing all the crystals in a general direction at right angles to their direction of growth and parallel to the walls of the fissure. This dark band, which is usually about a quarter of a centimeter in thickness, is made up of free gold, galena, sphalerite, and a minute amount of some unknown telluride, all in very small particles embedded in the quartz. After this the quartz crystals continued to grow outward for another 2 or 3 centimeters, containing in this portion only scattered specks and bunches of ore minerals. The direct outward growth of the quartz crystals now stopped and there was deposited upon the wavy surface defined by their pyramidal terminations a succession of at least 6 distinct coatings, differing in color, composed of cryptocrystalline aggregates of quartz, calcite, fluorite, sericite, and a little chlorite, aggregating in thickness about one-fourth centimeter. Upon these coatings there was next deposited a layer, about one-half centimeter thick, consisting chiefly of finely divided particles of sphalerite, galena, and possibly other ore minerals. This is the most conspicuous dark band seen in the illustration. This band is succeeded by a delicately mottled pale-green aggregate of quartz, the grains of which sometimes contain free gold, calcite, sericite, and fluorite, with dark patches of ore. This aggregate does not exhibit the characteristics of material that has crystallized freely in open spaces and is probably, in part at least, altered and replaced country rock. Variations from the foregoing structure are met with in various parts of the Camp Bird lode, but the specimen described is thoroughly characteristic of the richest ore and illustrates well its curious and beautiful banding (fig. 9). The conspicuous dark band, locally designated "the worm," is the miners' sign for good ore in this mine.

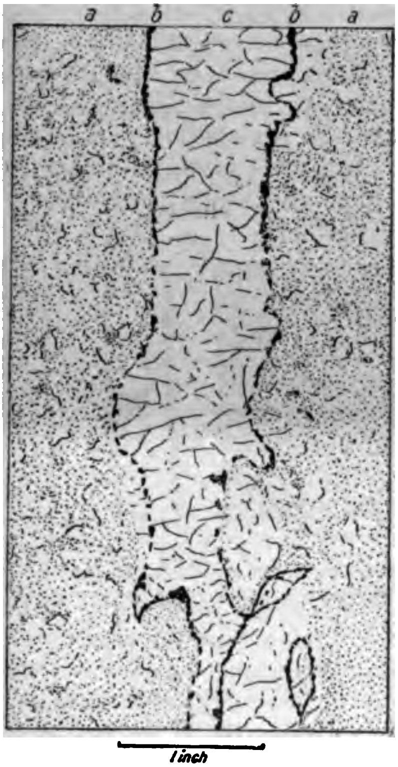

FIG. 9.—Section through a rich ore band in the Camp Bird lode. *a*, quartz, fluorite, calcite, etc.; *b*, ore particles including free gold; *c*, quartz.

In the Tom Moore mine the pay streak frequently consists of chalcopyrite in the middle with tetrahedrite on each side, the latter fading off into the altered country rock.

3. Brecciated structure.—Ore formed at an earlier period of deposition has been broken into angular fragments by renewed movement along the fissure, and recemented by fresh deposition of the ore or gangue.

Ore so shattered as to come under this head has not been noted as a conspicuous feature of any important deposit, although some brecciation can often be detected. The structure, however, is best exemplified by material from the dump of the Red Cloud mine, in which an original deposit of radially fibrous pyrite has been broken up and held together by a younger accumulation of vein quartz carrying a little sphalerite and galena (Pl. XI, *C*), and also by vein filling from the Polar Star and Palmetto mines. In the Red Cloud occurrence not only have the concentric shells of pyrite been broken up, but in some cases exceedingly thin coatings or sheets of the sulphide have been floated or moved out into the quartz, and in the polished specimen from which Pl. XI, *C* was made these delicate curved films embedded in the quartz resemble the finest cloisonné work of the Japanese.

4. Cellular structure.—The quartz or other vein material has crystallized as a mass of irregularly intersecting septa, leaving numerous drusy cavities separated by relatively thin walls.

This is not a structure characterizing any important ore deposit, and was not seen in place. But it is of interest in view of the possible light that it may throw on the processes by which the vein-forming materials are deposited. The structure is best exemplified by fragments on the dump of the Pride of Syracuse mine and on an upper dump of the Empire group, Sultan Mountain. In the latter case the septa are composed chiefly of sphalerite and galena, and the cells are lined with drusy quartz and in some cases filled with rhodochrosite. Beautiful little crystals of amber-colored sphalerite and of tetrahedrite were observed in some of the cells, implanted upon quartz. It is possible that this cellular structure may have resulted from some kind of pseudomorphous replacement coupled with the solution and removal of some unknown mineral.

5. Spherulitic structure.—The quartz of a vein has crystallized in prisms, often imperfectly formed, which show a marked tendency to group themselves in radial fashion about local centers of crystallization. It is not intended to treat specially under this head such minerals as tremolite, which exhibits characteristically a radial structure.

A rough spherulitic crystallization, previously described by Purington,[1] was noted in the gold quartz of the Tomboy mine and, in connection with banding, in the Camp Bird lode. It is also a notable feature of the North Star lode, where worked in the Dives mine (see

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[1] Preliminary report on the mining industries of the Telluride quadrangle, Colorado: Eighteenth Ann. Rept. U. S Geol. Survey, Pt. III, 1898, p. 840.

Pl. XI, *A*), and of the Magnet lode. The quartz in this case has often grown radially outward from kernels of tetrahedrite. Less conspicuous radial structure was noted in the Silver Queen, at the head of Placer Gulch.

MICROSCOPICAL FEATURES.

In the larger lodes, with massive structure, particularly those carrying much galena, the crystallization is, as a rule, so coarse that microscopical study is of use only in furnishing details of mineralogical structure. The quartz of such lodes shows the usual character of vein quartz, and has crystallized in large, irregular grains, interlocking with one another and with the principal ore constituents. The structure, when sufficiently fine to be embraced in a thin section, is typically hypidiomorphic granular (Pl. IX). Microscopic fluid inclusions with gaseous bubbles, often arranged along curved surfaces within the quartz, are always present. No special investigation of the hermetically inclosed liquids of these minute cavities has been made for this region, but they are probably solutions of calcium and alkaline sulphates, with some chlorides, and very likely carbonic acid.[1] Interstitial or miarolitic cavities into which the quartz crystals sometimes project are common, and are often filled with calcite, or, in the Silver Lake Basin, with chlorite (Pl. IX, *A*).

Vein quartz varies widely in the size of the constituent crystal grains. In the Sunnyside and neighboring lodes the galena, sphalerite, and chalcopyrite are distributed through the gangue in smaller particles, and the quartz grains themselves are correspondingly smaller than those in the Silver Lake veins. Pl. IX, *B*, shows a typical thin section of Sunnyside ore, in which chalcopyrite and sphalerite happen to be the dominant ore minerals.

Still other ores, of which that of the Ridgway mine may be taken as a type, exhibit throughout much finer crystallization. The quartz occurs in small interlocking grains, and the ore particles, which in hand specimens are often so small as to render the quartz cloudy or black, without being themselves individually noticeable, are seen under the microscope to be thickly sprinkled through the gangue and to be very irregular in shape. They occur both in the sutures between the quartz grains and within the grains themselves (Pl. X, *A*). Such ore is almost invariably said by the miners to contain brittle silver. But neither chemical tests nor the microscope reveal stephanite. In the Ridgway ore the particles are chiefly argentite with some pyrite, a little sphalerite, and sometimes a little galena. These finely crystalline ores are worked for silver and gold, as the galena is rarely abundant enough to pay for extraction. But they are by no means equally rich. In some cases the finely disseminated ore particles are chiefly argentiferous galena, sometimes a lead sulphobismuthite, and occasionally tetrahedrite. Proustite (ruby silver) was noted in the Ben Butler mine, with finely crystalline galena, which is erroneously called brittle silver by the miners.

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[1] Gold-quartz veins of Nevada City and Grass Valley districts, by Waldemar Lindgren: *Seventeenth Ann. Rept.* U. S. Geol. Survey, 1896, Pt. II, p. 131.

The gangue of the rich ore of the Camp Bird mine shows several interesting variations in its microstructure, and differs from that of any other lode known in the quadrangle. A characteristic structure and mineralogical composition is that shown in Pl. X, *B*, where quartz, calcite, and fluorite are crystallized together. This is a common appearance of the pale-green, finely crystalline aggregate which has crystallized concentrically outside of the dark, wavy ore band shown in Pl. XII, *B*. The quartz here shows a distinct tendency toward idiomorphic form, and in sections transverse to the prism usually reveals, in polarized light, a zonal structure the outer shells of which are composed of shadowy sectors differing in their interference tints (Pl. X, *B*). These quartz grains contain inclusions of chlorite and a mineral in acicular crystals too small for identification. The inclusions are most abundant near the center of the crystal. The fluorite is not always present, and the gangue is frequently much more finely crystalline and often shows nests of sericite. This portion of the gangue has evidently crystallized in part in open spaces, but it has also undoubtedly in part resulted from a metasomatic replacement of the San Juan breccia adjacent to or included within the main fissure zone. The microscope shows the free gold to occur in nests of minute hackly particles solidly embedded in quartz. It is apparently most abundant in the coarsely crystalline, vitreous, radial quartz (see Pl. XII, *B*), but also occurs in the quartz just outside of the dark ore band already referred to. As seen under the microscope this ore band consists of particles of galena, light-yellow sphalerite, and chalcopyrite in quartz. The gold was not seen in the dark band itself, but is nearly always within a few centimeters of it, usually associated with a little galena and sphalerite.

Although as a rule the ores occupy filled fissures, yet in a few cases the gangue in which the ore occurs is composed wholly or in part of country rock which has been altered to an aggregate of quartz, and usually one or more of the following minerals: Calcite, sericite, kaolinite, chalcedony, fluorite. Such aggregates generally differ from true vein filling in showing under the microscope a much finer crystallization of their constituents into a mosaic which is more or less cloudy when seen between crossed nicols. The grains of quartz seldom exhibit the clear, definite boundaries seen in vein filling, such as is shown in Pl. IX. Moreover, the sericite and calcite are often grouped in areas whose form is that of former feldspathic phenocrysts. This structure, however, will be more fully described in the section on the metamorphism of the country rock.

AREAL DISTRIBUTION OF THE LODE ORES.

The various mineralogical and structural types of ore are not distributed at random over the quadrangle, but a given portion of the area is often characterized by ore of a certain kind, differing from those which preponderate in other portions. These areal subdivisions are not sharply bounded, and it often happens that in a district in which most of the lodes contain a certain type of ore there will occur other ores which are more characteristic of some other district in the quadrangle. But, notwithstanding these transitions and exceptions, the localization of ore types is a striking feature of the region.

The lodes traversing the mass of Sultan Mountain are quite commonly filled with rather coarsely crystalline vein filling, carrying galena, tetrahedrite, and chalcopyrite, with some sphalerite and pyrite, in a gangue of quartz and barite. Their chief value is in silver. The most productive of these lodes has been the North Star, which produced an ore running about 40 per cent lead and 70 ounces of silver. This lode is in monzonite, but mineralogically similar ore is found in the King lode in Algonkian schists, said to carry about 0.1 ounce of gold, 55 ounces of silver, and 15 per cent of lead. The ore of the Empire group of veins is generally similar in character.

Southeast of Silverton, in the vicinity of Deer Park, are numerous mineralized fissures cutting the schists and granites, and in some cases the overlying San Juan breccia. These are occupied, as a rule, by quartz veins carrying pyrite, with a little galena, sphalerite, and chalcopyrite. They are prospected for gold, which occurs free in small pockets. Compared with most of the lodes in the quadrangle these veins are not heavily mineralized, and are not mined on an important scale.

The lodes of Silver Lake Basin are characterized by coarse, massive structure and are heavily mineralized. Galena often exceeds all other constituents of the vein filling in amount, and lead is an important factor in the output. Sphalerite and chalcopyrite accompany the coarsely crystalline galena, and there is usually some pyrite present. The gangue is quartz, often containing chlorite. Tetrahedrite occurs sporadically in many of these lodes, and barite was noted in the Royal Tiger workings. These are generally low-grade concentrating ores, averaging from $8 to $15 per ton. Free gold is rarely seen, but the gold tenor in some of the lodes of Group II (see p. 147) may rise to 2 or 3 ounces per ton. In the Silver Lake mine about half the value of the output is from the gold; the remainder being in silver, lead, and copper. The other mines contain less gold, and the Royal Tiger mine depends chiefly upon its lead. Most of the ore of Hazelton Mountain appears to have been of the general type just outlined. A thousand tons from the Aspen mine is said to have produced 110 ounces of silver per ton and 60 per cent lead, although the average tenor was somewhat less than this. An exception of the sort referred to at the beginning of this section is afforded by the Little Giant lode, on the north side of Arrastra Gulch, which produced a free-gold ore.

In Maggie Gulch the greater number of the lodes contain siliceous ores, of which that of the Ridgway mine may be taken as the general type (Pl. X, *A*). In these ores the quartz is finely crystalline and the ore minerals occur as minute dark specks, which, when abundant, give the gangue a dark, clouded appearance. In the Ridgway, the only mine working these ores on a commercial scale, the ore particles are chiefly argentite. But in other cases they are galena, and apparently not always very argentiferous. The erroneous belief of the prospectors that these minute ore particles are nearly always "brittle silver" has in some cases resulted in much fruitless labor. In one instance a prospecting tunnel of considerable length was being run on expectations excited by a few minute bunches of "brittle silver," which were in reality worthless specularite. Ores generally similar to those of Maggie Gulch occur at various points in the northeastern part of the quadrangle, particularly in the vicinity of Mineral Point.

In Sunnyside Basin and at the head of Placer Gulch the ores are commonly of moderately coarse crystallization and carry abundant galena, sphalerite, and chalcopyrite. They are almost invariably associated with abundant rhodonite. Of low grade as a whole, they sometimes contain bunches of rich ore, which, in the Sunnyside Extension mine, are known to have carried, in carload lots, as much as 74 ounces of gold per ton, mostly free. The ore of the Sunnyside mine may be considered as typical of this district.

In Poughkeepsie Gulch the ores partake somewhat of the characteristics of those of the Sunnyside Basin and of Mineral Point. But their most characteristic feature appears to have been in the occurrence of the lead and silver in some combination with bismuth, usually as an argentiferous sulphobismuthite of lead. The ore of the Alaska mine is a well-known example and has been described on page 195.

In the extreme northeast corner of the quadrangle many of the prospects and some of the mines formerly worked are characterized by argentiferous copper ores, usually chalcocite or bornite, with some galena and chalcopyrite.

What may conveniently be termed the Red Mountain Range, embracing the region bounded by Cement, Grey Copper, and Mineral creeks, is characterized by the predominance of the stock deposits and their peculiar ores, which will be described in subsequent pages.

Lastly, in the northwest corner of the quadrangle, ores carrying much galena, and recalling in some of their features those of Silver Lake Basin, are associated with gold ores such as those of the Camp Bird and Tomboy mines.

As far as could be determined, the distribution of ore types as briefly sketched in the foregoing paragraphs is purely areal and is not dependent upon kind of country rock or direction of fissuring. Finally, emphasis should again be laid upon the fact that there is much overlapping and intermingling of types, and that ores of many kinds may occur in any given limited district. Free-gold ores, in particular, may be expected to occur in any part of the quadrangle.

DISTRIBUTION OF THE ORES WITHIN THE LODES.

Lodes are seldom equally well mineralized in all portions. Those parts of a lode or vein which are sufficiently large and rich to be profitably worked are commonly known as pay shoots or ore shoots, sometimes spelled ore chutes. The first term is regarded as preferable, inasmuch as it expresses concisely the thing meant, and can not be confounded with the ore chutes or mill holes of timber through which ore is drawn from the stopes into the mine levels. A pay shoot is obviously not a thing capable of exact delimitation. Its size and shape depend to some extent on fluctuations in the metal market (unless purely a gold ore) and on variations in the operating expenses of the mine. But the concentration of ore in certain portions of a lode separated by unprofitable lode matter is a very important phenomenon, and one that can, as a rule, be studied and discussed only as it is revealed in the exploitation of pay shoots by actual stoping.

A complete study of pay shoots requires good stope maps, carefully revised to date, and an advanced stage in the development of the lodes. Except for a few localities, these favorable conditions are not found in the Silverton quadrangle. The advantage in all future development of having a record of past work is not always fully realized, and the miner is too often content simply to follow his ore where he finds it, adapting his work merely to the needs of to-day. In simple lodes with continuous pay shoots this rough-and-ready mining may succeed well enough. But in complex lodes, or in groups of lodes, such as those of the Silver Lake mine, systematic mapping and the adaptation of the development to future probabilities may mean success where the more ordinary method would result in failure. On account of the general absence of accurate stope maps and the small depth of most of the mines operating in the quadrangle the following observations on the pay shoots are fragmentary and often unsatisfactory.

In most of the workable veins and simple lodes, such as those of Sultan Mountain and Silver Lake Basin, pay ore is usually, although not invariably, found wherever the fissure is wide enough to hold an ore body. This appears to be particularly true of the New York City, Stelzner, Royal, and Iowa veins. Thus, in these veins, distinct pay shoots, separated by stretches of barren lode, do not properly occur, or have not been demonstrated by mining operations. The pay shoots take their shape, as a whole, from the form of the fissure. A partial exception to this is found, however, in the impoverishment of the lodes of Group II as they approach the Silver Lake lode, which is itself of lower grade, and in occasional spots where the lodes retain their width but are too low grade to work. The pay shoots of these lodes also grow longer with depth, which is apparently due to the increasing length of the fissures in connection with the dip of the Silver Lake lode. In the Silver Lake lode the pay ore is found in bunches of varying size; but as these bunches usually occur wherever the filling of the fissure is wide and firm they probably do not constitute a marked exception to the foregoing general rule. In the Royal Tiger mine not enough work has been done to reveal the real shape and extent of the ore body. In the North Star mine, on Little Giant Mountain, the ore occurred irregularly in a stringer lead, but the old stope maps show the pay shoot as a whole to have been about 700 feet in length on the levels and to have pitched to the southeast. Other small ore bodies were found farther in the mountain, to the northwest. In the Sunnyside and Sunnyside Extension mines the pay shoots are mainly lenticular bodies 30 or 40 feet in length, lying on the hanging or foot wall side of the lode, or between plates of rhodonite. Owing to the lack of maps, the exact sizes and shapes of these ore bodies are not known.

In the Silver Queen mine, on Bear Creek, the ore occurs in three separate pay shoots, pitching south and separated by from 12 to 15 feet of lean quartz. The northern pay shoot consists of low-grade chalcopyrite, with subordinate galena and tetrahedrite. The middle ore body is rich in an argentiferous sulphobismuthite of lead associated with galena, but changed to chalcopyrite in stoping upward from the tunnel level. The south pay shoot is almost wholly galena. The development of this mine is very superficial and the three pay shoots may, with more extensive workings, be found to be simply portions of one ore body.

In the Camp Bird mine the pay shoots, so far as known, appear to be coextensive with the lode, disappearing only where the fissures locally contract to a mere crack. What is known as the west pay shoot is about 1,200 feet in length, and others occur along the lode, separated by pinches. The pay shoots are stated to be increasing in length with depth. As previously pointed out (p. 89), the auriferous portion of the lode lies next the hanging wall, with a silver-lead streak near the foot wall.

In the Tomboy, also, the pay shoots, as indicated by the stopes, are long, and are practically identical with the lode itself, disappearing only where the latter is pinched. According to Mr. John Herron, superintendent, the pay shoots lie flat in the lode, one above another, and extend diagonally across from wall to wall. They are said, moreover, to be often connected with certain post-mineral fractures which cross the vein diagonally in the same direction (see p. 209). There was no means of verifying these statements, and such minor pay shoots, with the intervening lower-grade quartz, are all stoped out i working and would not appear in an ordinary stope map. It i beyond question, however, that in this mine the best ore occurs i quartz which has been crushed by movements subsequent to it original deposition. The solid, unbroken, unstained quartz is invariably of somewhat lower grade. As in the Camp Bird, the auriferou ore is next the hanging wall, a silver-lead streak lying near the foo wall.

From large, regular pay shoots, such as are found in the New Yor City, Camp Bird, and Tomboy lodes, all gradations may be foun through smaller, more irregular ore bodies down to the occasiona small pockets of rich ore encountered in some of the lodes of Dee Park and Maggie Gulch.

The changes which take place in pay shoots with depth are exceedingly important in mining operations. Unlike the auriferous lodes o California, which rarely show any progressive or regular change i the character of their ores even to depths of 2,500 feet, the pay shoot of the Silverton quadrangle are less constant. It is a common belie among mining men of this region that lead ores do not go down t great, or even to moderate, depths. In part this opinion is plainl traceable to the experience gained in exploiting the stocks of the Re Mountain district, which will be described in subsequent pages; bu it is pertinent here to see how far it is justified by the known facts i regard to the lodes.

In the Aspen mine there are said to have been several veins nea the surface which came together at moderate depth. Below a dept of 800 feet the galena, which was very abundant in the upper levels is said by Mr. W. H. Thomas to have so diminished in amount as t make further work unprofitable. According to the same informan the ore of the Belcher mine, on Sultan Mountain, carried abundan galena of good grade in the upper workings, but this decreased i amount and value in the lower levels, while sphalerite grew mor abundant. Actual verification of these statements by observation i not now practicable, but Mr. Thomas, who had been connected wit both mines, was undoubtedly himself convinced of the truth of hi statements. In the Royal, Stelzner, New York City, Iowa, and Eas Iowa lodes there is no present indication of any diminution of galen or of any other regular change in the ore with increasing depth. Th ore of the New York City lode where cut by the Unity tunnel, abou 1,200 feet below the croppings, shows abundant galena, and is simila to the ore in the same vein on levels *C* and *J*, 400 and 700 feet respectively, above the Unity level. If anything, it is of highe grade. The Buckeye lode (part of the Titusville lode) has not bee exploited to great depth, but tetrahedrite was undoubtedly mor abundant in the upper than in the lower tunnel. In the North Sta mine, on Little Giant Peak, a change in the character of the ore i well authenticated by Mr. W. Crooke, the manager. For 200 feet below the croppings the ore was largely sulphate of lead (anglesite) with some galena, and did not carry much silver. Below that level it changed to unoxidized galena. With increasing depth the place of the galena was largely taken by argentiferous tetrahedrite, and in the lowest workings, about 600 feet below the cropping, there was very little galena found. The bottom of the pay shoot is said to have been reached in the lowest workings, although the fissure zone continues to an unknown depth and probably contains other pay shoots, which, however, may not be large or rich.

In the Polar Star mine, on Engineer Mountain, the ore, consisting of argentite and proustite, is said by Mr. W. Crooke to have changed abruptly to iron pyrite, carrying about 12 ounces of silver per ton and no gold. According to Mr. Crooke, this change was generally encountered at about the same level in all of the mines on this portion of the mountain. The exact depth at which the change took place is not known, but it must have been moderate, probably not more than 500 feet. In the Palmetto mine, on the northeastern extension of the Polar Star lode, the ore near the surface ran as high as $500 per ton, and contained ruby and so-called "brittle" silver (probably proustite and argentite), resembling that of the Polar Star mine. The lode struck in the shaft at a depth of 400 or 500 feet was of low grade, and, as the dump shows, contained much pyrite. In this, as in the case of the Old Lout and Pride of Syracuse, it is sometimes asserted that the lode found in the deeper workings was not the same as that which had been productive above. While a mistake of this kind is not impossible in individual cases, the threefold repetition of such a mischance in the Silverton region may be set down as highly improbable. The histories of the Pride of Syracuse mine on Engineer Mountain and of the San Juan Chief mine are almost repetitions of that of the Palmetto. The Old Lout lode, which produced rich bismuthiferous ore to the extent of several hundred thousand dollars from a shaft sunk on the lode, proved too poor to work when crosscut by a long tunnel from the bottom of Poughkeepsie Gulch, about a thousand feet below the croppings. The ore from this lowest level shows galena, chalcopyrite, sphalerite, and pyrite, about equally distributed in a gangue of quartz with a little barite. The U. S. Depository lode, in Richmond Basin, produced some galena ore in the upper workings, but where cut by a tunnel, at a depth of something over 500 feet, the lode proved worthless. In this case the lode is well defined, but shows scarcely any mineralization in the lower workings. In the Uncompahgre Chief, a prospect near Mineral Point, a shaft 50 feet in depth has passed through ore containing an argentiferous sulphobismuthite of copper and lead, into an ore of which pyrite is the chief mineral constituent. In the Dolly Varden mine, north of Rose's Cabin, according to Mr. James Abbott, good ore containing tetrahedrite and "brittle silver" (?) was found in the shaft, but no pay ore was encountered in a lower crosscut tunnel.

From the foregoing it appears that in this region pay shoots containing chiefly ores of lead, silver, and copper may change in mineralogical character and in value within very moderate depths. But while galena in one case has been succeeded by tetrahedrite and in another case partly by sphalerite, in other lodes containing silver-lead ore tetrahedrite (Royal Tiger and Buckeye mines) and sphalerite (Iowa lode) have been more abundant in the upper than in the lower workings. Thus the facts, as at present known, do not justify the general statement that galena passes into gray copper with depth, or vice versa. The change from galena to sphalerite with increasing depth is a well-known phenomenon in the lead and zinc deposits of southwestern Wisconsin, and is explained by Van Hise[1] as a result (1) of a first concentration by ascending waters and (2) of a second concentration by descending waters. It is possible that the change recorded in the Belcher is of this character. But the occurrence of abundant argentiferous galena and tetrahedrite in the Virginius lode at the Revenue Tunnel level, over 2,000 feet below the croppings, and of galena in the deepest workings on the New York City lode, indicate that both tetrahedrite and galena may occur abundantly and retain their values at far greater depths than were reached in the Aspen, North Star, and other mines of the Silverton quadrangle, in which the pay shoots are reported to have diminished in value or to have disappeared entirely. As applied to the lodes, therefore, the often-heard arbitrary dictum that galena and tetrahedrite "do not go down," in so far as it relates to the depths ordinarily met with in mining, is a generalization based on insufficient premises, although, as will appear in the discussion of the origin of the ores, there are theoretical reasons for supposing these minerals less likely than certain other sulphides to be found in abundance at great depths. With regard to the rich silver ores argentite and proustite, the known facts, incomplete as they are, seem to warrant the conclusion that these minerals occur in the upper portions of the lodes only, and do not extend to great depths, probably rarely over 500 feet in this region. This is in general accord with observations in other districts where these and other rich silver minerals occur, and, as will be later shown, this fact has an important bearing on the question of the genesis of the ores.

The vertical range of the argentiferous sulphobismuthites of lead occurring in the Silverton region is not known, but there are some indications that they do not extend to great depths.

The free gold ores have not yet been worked to a sufficient extent in the Silverton quadrangle to furnish any very reliable data as to their possible changes in value with depth. The indications, however, are in favor of a varying, but on the whole more nearly constant, tenor as they are mined to greater depths, than in the case of silver-load ores. It is fair to assume that the considerable depth to which the lodes of California have been mined without revealing any regular increase or decrease in the tenor of the pay shoots below the zone of oxidation is something more than a mere local phenomenon, and holds for gold-quartz lodes somewhat generally, provided that the fissures are continuous and the country rock is uniform.

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[1] Some principles controlling the deposition of ores: Trans. Am. Inst. Min. Eng., Vol. XXX, *1900, pp. 104-109.*

RELATION OF ORES TO KIND OF COUNTRY ROCK.

As far as known, the influence of the country rock upon the deposition of the lode ores in the Silverton quadrangle is small. Extensive productive ore bodies occur in monzonite and in the volcanic rocks of both the Silverton and San Juan series; and, although none are worked in the Algonkian schists, there is no indication that, given a suitable fissure, ores would not be deposited as readily in these as in other rocks. The influence of the wall rock upon ore deposition appears to be limited to a tendency toward impregnation and replacement in the deposition of ores in some of the rhyolitic and andesitic flow breccias and tuffs. This, however, is a phenomenon relating to the form of the deposit, and to the subject of the alteration of the wall rocks rather than to the character of the ores themselves.

SECONDARY ALTERATION OF THE LODE ORES.

Owing to the fact that erosion in this high region is effected by mechanical disintegration rather than by secular decay, the oxidation of the ores is not, as a rule, very extensive, and is sometimes negligible. In the North Star mine, on Little Giant Peak, oxidized ore, consisting chiefly of anglesite, is reported to have extended to a depth of 200 feet. Ordinarily, however, complete oxidation is very superficial, although traces may be found at much greater depths than 200 feet. Carbonate and sulphate of lead and carbonates of copper, often associated with the unaltered sulphides, occur in the croppings of most of the lodes carrying galena and tetrahedrite or chalcopyrite. In the Silver Lake mine sulphate and carbonate of lead occurred abundantly in the highest level (No. 4) with unoxidized ore. At the level below, however, the secondary ores were unimportant. As is commonly the case in this region, there is no sharp line separating an upper zone of oxidation from the sulphide ores. The decomposition of the original ore minerals has penetrated irregularly downward wherever oxidizing waters found opportunity to descend, and is seldom limited by a distinct water level. Very commonly the level of permanent water lies far below the oxidized portion of the lode. In the Tomboy and Camp Bird mines black oxide of manganese occurs in the deepest workings and usually indicates good ore. In these cases the oxide appears to be associated with post-mineral fracturing and crushing and to hav been deposited later than the bulk of the ore. In the New York Cit lode of the Silver Lake mine a sooty, amorphous sulphide of coppe occurs with pyrite, chalcopyrite, galena, and sphalerite. This i probably of secondary origin, and although not a product of ordinar oxidation is yet considered as due to descending waters percolatin downward from the zone of weathering above.

ORIGIN OF THE LODE ORES.

Although the ores of the lode present many features not found i the stock deposits of the Red Mountain district, yet in the essenti points of their origin they possess so much in common that it woul be impossible to treat the two forms of deposit separately withou much overlapping. Accordingly the question of the origin of the lod ores will be left in abeyance until the stocks have been described.

VALUE OF THE LODE ORES.

Generally speaking, the lode ores of the Silverton quadrangle ar of low grade and require careful mining and milling to yield profi able returns. The ores which are or have been worked vary in valu from a probable minimum of about $6 to several thousand dollars pe ton. The extremely high values, however, are for ores carrying fre gold occurring only in small amounts in pockets in otherwise low grade lodes, or in very small veins, such as the Golden Fleece. Fro the Sunnyside Extension mine, however, ore was obtained in carloa lots carrying $1,500 per ton in gold alone, as shown by the smelte returns. In the Silver Lake Basin the ores worked probably var from $8 or $10 to $60 or $70 per ton, according to the proportion o lead, silver, or gold which they contain. The average of the ore fro the Iowa mine is not far from $12 per ton, although in places it ma contain from 2 to 3 ounces of gold, thus affording much higher returns The general average of the Silver Lake mine is probably higher, a half the value of its output is in gold. The ore of the Royal Tiger is on the other hand, somewhat lower, the product being chiefly in lead The North Star mine, on Sultan Mountain, was producing quantitie of ore in 1882 carrying, according to the Mint reports, 40 per cent o lead and 70 per cent of silver. At the commercial values for tha year this would mean an ore of about $120 per ton, gross value, or, a present prices, about $72 per ton. The Aspen mine is said to hav produced one lot of 1,000 tons of ore containing 110 ounces of silve and 60 per cent of lead, which at present prices would correspond t about $110 per ton. The average value of the ore from this mine was however, probably less than half this. The shipping ore from th Ridgway mine, containing finely disseminated argentite, is reporte to average about $110 per ton, of which about 3 ounces is in gold an the rest in silver. The free-gold ore of the Tomboy mine average about $20 per ton, of which $19 is in gold. The most uniformly ric ore now worked in quantity in the quadrangle is undoubtedly the gold ore of the Camp Bird. This is all milled, and averages from $40 to $200 per ton as delivered at the stamps. The gold ore of the Gold King mine is generally of low grade and can be worked to about as low a limit as any in the quadrangle.

THE STOCKS OR MASSES.

DEFINITION AND GENERAL DESCRIPTION.

As defined by Von Cotta,[1] ore stocks are irregular bodies of ore possessing distinct boundaries. They differ from veins or lodes in the absence of a characteristic tabular form, and from impregnations in being fairly solid masses of ore with definite limits, or, in the case of stockworks (Stockwerke), of a great number of small veins or ore bodies constituting a mass which is worked as a whole. Phillips[2] has translated Von Cotta's *Stöcke* as "masses," but this word is so general in its scope and has been used in so many classifications with varying significance that it is here discarded as a definite descriptive term. The nearly vertical ore bodies of the Red Mountain district, sometimes locally known as "chimneys," are substantially what Von Cotta has described and defined as standing (or upright) stocks.

The stocks of the Silverton quadrangle are nearly vertical, irregularly lenticular or spindle-shaped bodies of almost solid ore, surrounded by an envelope of much altered, partly silicified country rock, which is usually impregnated with pyrite. Neighboring ore bodies are commonly connected by fissures, usually filled with wet clay gouge or kaolin. The sizes of the individual ore bodies vary greatly. In plan, lengths of 40 or 50 feet and widths of 10 or 15 feet appear to have been not uncommon. Accurate sections of actual stocks are not now available, but individual ore bodies appear to have been followed in many cases through several levels, and therefore to have had a nearly vertical maximum dimension of several hundred feet. Although sometimes nearly circular, the ore bodies generally showed a more or less elongated or elliptical plan, the longer axis of which usually lay more nearly north and south than east and west. The direction of the longer axis was not, however, always constant for all depths of a given stock.

The ore bodies, particularly in the deeper workings, were usually found within nearly vertical zones of fractured, altered country rock, locally known as "ore breaks." Mr. T. E. Schwarz, who appears to have originated this term, says:

> The ore bodies of the Red Mountain district occur as chimneys or chutes, having great persistence in depth and varying greatly in dip and cross section, but ramifying toward the surface. The outcrops of these ore chutes occur along lines of alteration of the andesite or inclosing rock, and such lines were undoubtedly fracture planes of greater or less extent. These fracture planes or belts of metamorphosed andesite were in the early days of the district termed by me "ore

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[1] Erzlagerstätten, p. 191, Freiberg, 1859.

[2] Op. cit., p. 4.

breaks," to signify the character of the rock along the line of which the ore chimneys occurred or might be expected to occur. They were not fissure veins, in that the ore bodies did not confine themselves to any given plane, and in following them no definite course either laterally or vertically could be counted upon ahead of exploration. The course of an ore break I have frequently found to change 90° in a depth of several hundred feet.[1]

DISTRIBUTION.

The stocks do not occur in all portions of the quadrangle, but are limited to a small, well-defined area, which corresponds mainly to the crest and westerly slope of what may be termed for convenience the Red Mountain Range. This district is bounded on the northeast by Grey Copper Creek, on the northwest by Red Creek, on the west and south by Mineral Creek, and on the east, with one or two exceptions near Red Mountain, by the ridge crest extending from Anvil Mountain northward to Red Mountain and thence northeast to the saddle at the head of Grey Copper Gulch. The area thus outlined has certain characteristic features, apparent to the most unobservant eye. There is scarcely an exposure of rock within it which has not been bleached, silicified, or otherwise altered, and the whole has been more or less thickly impregnated with fine crystals of pyrite. The iron originally contained in this pyrite, through weathering and oxidation, has given to the Red Mountain Range the beautiful coloring for which the region is noted, blending from the deepest red, through vermilion and orange tints, to the most delicate yellows and grays.

The greater part of the deposits, and all of the more important ones, are closely grouped in the northwestern part of this area, in a belt less than a mile wide and about 4 miles long, extending from Ironton to a point about a mile south of Red Mountain village.

Although no continuous fissures or veins can be detected on the surface, it is noteworthy that the St. Paul, Congress, Senate, Hudson, Enterprise, Charter Oak, Genesee-Vanderbilt, Yankee Girl, Robinson, Guston, White Cloud, and Silver Bell mines all lie close to a straight line bearing about N. 21° E. The National Belle, Paymaster, and Grand Prize mines, and a host of less-noted claims, are apparently irregularly disposed on either side of this line. (Fig. 10.)

South of the vicinity of Red Mountain the stock deposits are scattered and have not proved of much importance. The only one which has produced ore in important amounts is that of the Zuñi mine, on Anvil Mountain, which, however, is interesting chiefly as the source of the minerals guitermanite and zunyite.

ORIGIN OF THE SPACES NOW FILLED WITH ORE.

In seeking the origin of the ore spaces, there are, in spite of the present obstacles in the way of complete investigation, certain facts

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[1] Trans. Am. Inst. Min. Eng., Vol. XXVI, 1896, p. 1057.

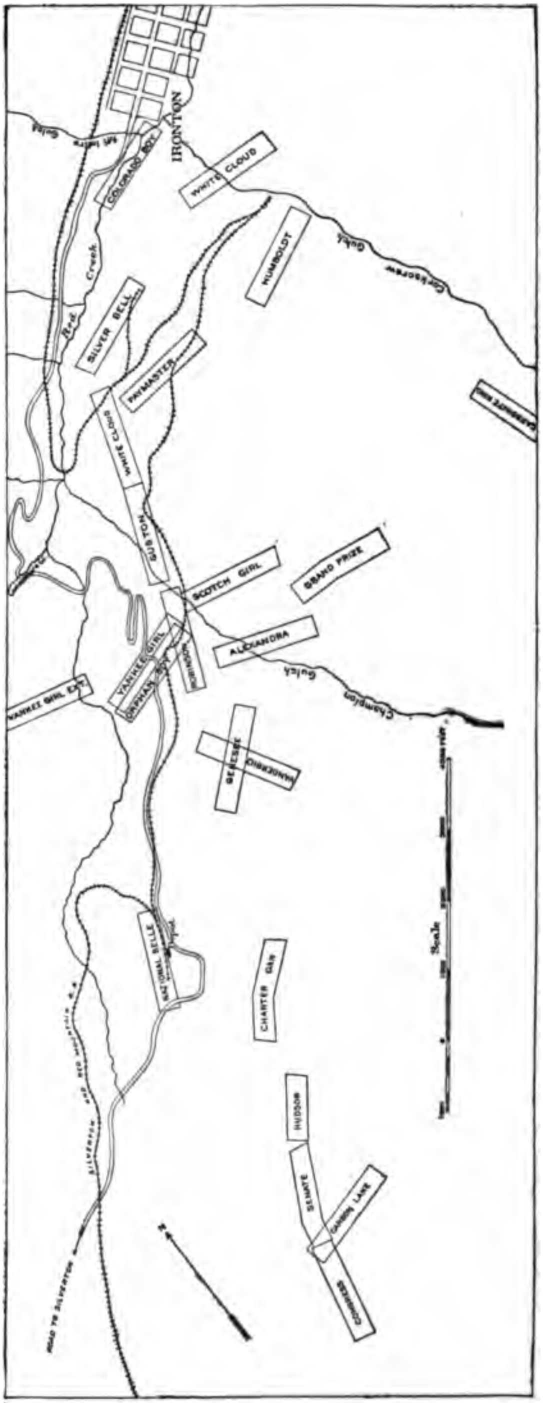

Fig. 10. Map of the principal mining claims in the Red Mountain region.

which may be considered as established and which bear directly upon the problem. No solution can be considered as satisfactory which does not take them into account. They will therefore be briefly summarized.

The greater number of the productive ore bodies in the Red Mountain district, such as the Congress, Hudson, Yankee Girl, Guston, and Silver Bell, lie on or close to a line bearing about N. 21° E., which is probably a line of dominant fracturing. It is very probable, if not demonstrable, that a second nearly parallel zone of fractures extends through the ground of the National Belle mine southwesterly, past Summit and down Mineral Creek, to the Silver Ledge mine, near Chattanooga. The general course of this line is N. 30° E. The ore spaces are more or less irregularly spindle-shaped or ellipsoidal, with the longest axis commonly nearly vertical. The country rock in the vicinity of the ore spaces is usually much, and rather irregularly, fissured. Neighboring ore bodies are commonly connected by fissures, and this fact was taken advantage of in prospecting. When the ore spaces are elongated or elliptical in plan, the longer axis generally, although not always, lies a little east of north. In the Guston claim the ore spaces usually occur in what is called the "ore break," a zone of fissured country rock striking N. 20° or 30° E. Similar "ore breaks" were recognized in the Genesee-Vanderbilt and in other mines. The country rock adjacent to the ore spaces is much altered, as described under metamorphism, pages 124–131, and is often thickly impregnated with fine pyrite. Mr. S. F. Emmons has recorded what seemed to him to be undoubted replacement of country rock, especially of the Silverton breccia, by ore, and even the limited observations now possible show that some replacement undoubtedly took place in both the Yankee Girl and Guston mines.

It is believed that the explanation most consistent with the facts above stated and with others presented in the detailed descriptions of the mines is that the ore spaces were formed primarily by complex, intersecting fissuring, and were enlarged both by solution and by metasomatic replacement. The dominant fissuring seems to have been in a direction between 20° and 30° E. of N., and is well shown along two principal zones. But there was also much minor fracturing in various other directions. At the intersections of two or more of these fissures the country rock was usually brecciated and furnished channels for the ascending currents of warm or hot mineral-bearing waters which effected the pronounced hydrothermal metamorphism so conspicuous in the rocks of this particular district. That such waters were capable of considerably enlarging the irregular conduits through which they circulated, either prior to or during the deposition of the ore, seems likely when the shape of the ore spaces and the extent to which the rocks in their vicinity have been altered are taken into account. It must be admitted, however, that in the case of the small Zuñi ore body no such solvent action was detected. The foregoing explanation is essentially that proposed by Emmons[1] in 1888, when he pointed out the similarity existing between the Yankee Girl mine and the Bull Domingo and Bassick mines in the Silver Cliff district, Colorado. As described by L. R. Grabill,[2] the Bassick ore body fills an irregular opening nearly elliptical in plan and varying from 20 to 30 feet on the shorter diameter to nearly 100 feet on the longer. It extends vertically downward for nearly 800 feet. No walls have been found, and there is no distinct boundary between ore and country rock. Emmons[3] concluded that the ore body was due to fumarolic action in the throat of a volcano after all explosive action had ceased. He remarks, however:

> It would appear * * * that it was the intersection of certain fracture planes that determined the course of the ore-bearing channel, and that the ore body is not necessarily the center of the volcanic vent, but that, as a second ore chimney has already been discovered on one side of the first, it is by no means impossible that other chimneys or ore shoots may exist in the body of the agglomerate, which might be discovered by judicious and systematic exploration in the direction of the principal fracture planes.

In the Bassick mine the ore was deposited in the agglomerate, replacing the fine interstitial tuff and partly replacing the larger volcanic fragments.[4] It will be recalled that a somewhat similar replacement of the San Juan breccia by ore was noted by Mr. Emmons in the Yankee Girl mine (p. 216). In the Bull Domingo mine "the ore occupies a nearly vertical chimney-like channel in a conglomerate or breccia mass, and the minerals are deposited in concentric scales around the bowlders or rock fragments."[5] This ore channel "was primarily formed by a complicated intersection of a number of fracture planes which produced a zone of broken country rock, in which the included fragments may have been somewhat rounded by attrition, but whose final rounding was more likely completed by the solvent action of percolating solutions."[6]

It is evident from the descriptions given of the Red Mountain stocks that the term "chimney" applied to them is somewhat misleading. They are not simple vertical pipes of ore extending from the surface to indefinite depths, but are separate bodies of irregular, lenticular, or spindle-shaped form, often completely inclosed by country rock, but linked with neighboring stocks by fissures which are often small and which carry little or no ore. There is no evidence whatever to indicate that they occupy the necks of former volcanoes. Although they occur in volcanic breccia, it is the normal andesitic breccia of the Silverton formation, which covers hundreds of square miles of the San Juan region, and is in no sense an agglomerate filling a volcanic neck.

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[1] Structural relations of ore deposits: Trans. Am. Inst. Min. Eng., Vol. XVI, 1888, pp. 833-834.

[2] On the peculiar features of the Bassick mine: Trans. Am. Inst. Min. Eng., Vol. XI, 1882, p. 110.

[3] The mines of Custer County, Colo.: Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. II, 1896, p. 436.

[4] S. F. Emmons, loc. cit., p. 438.

[5] Emmons, loc. cit., p. 445.

[6] Emmons, loc. cit., p. 446

Another common explanation is that the Red Mountain stocks occupy the throats of extinct geysers and hot springs. The supposition that the ascending heated waters which were primarily instrumental in forming ore bodies may have issued as hot springs, or even geysers, from a former surface, is of course perfectly tenable and difficult to disprove. But to argue that the knolls of silicified and impregnated andesitic breccia conspicuous in the topography of to-day are really mounds of siliceous sinter is to be carried away by an analogy of the most unessential and superficial kind. The knolls exist merely because the bleached and altered rock of which they are composed resists erosion better than the crumbling, more easily weathered breccia, which has been less affected by the mineralizing solutions and is more readily disintegrated and carried away by rains and streams.

It seems most reasonable to regard the ore spaces of the Red Mountain district as a local modification of the general fissuring of the region. It is possible, however, that much of the minor, very irregular fissuring which is characteristic of this region may be due to contraction within the rock mass consequent upon the prevalent alteration of the volcanic rocks to aggregates of quartz, kaolin, and pyrite, with the removal of certain constituents, as more fully discussed on pages 114–131. Not only was the fissuring locally complex, but the ascending thermal waters had more chemical and probably more physical activity than elsewhere within the quadrangle, whereby solution played an important part in enlarging zones or aggregations of fractures into ore spaces and in metamorphosing the country rock to an extent not elsewhere observed in this region. The cause of this local intensity of chemical and physical activity is not known, although it is probable that the circulating intratelluric waters were here hotter and more copious than elsewhere. Some indication of the latter is afforded by the abundant strongly mineralized springs which issue from the surface in this district at the present day. There is, moreover, some geological grounds for believing that the Red Mountain region may have been formerly a local center of volcanic activity.

There has probably been fracturing of the rocks, or at least movement along preexisting fissures, since the ore bodies were formed, but there are not at present facilities for studying the relation of the older to the later fissures. It may even be considered doubtful whether the so-called fault found below the seventh level in the Guston and the sixth level in the Yankee Girl is entirely a postmineral dislocation, or whether it is in part a fracture antedating the deposition of the ore.

CHARACTER AND STRUCTURE OF THE ORE.

It is very difficult, on account of the present condition of the mines, to give a satisfactory account of the mineralogy and structure of the ores occurring in the stocks. The chief difference between these ores and those occurring in the lodes seems to have been the fact that the former occurred in nearly solid masses, with very little gangue. The occurrence of enargite, moreover, is apparently peculiar to the stock deposits in this region, the mineral not being known in the lodes. It does not, however, occur in all of the stocks. The more common ore minerals of the latter are galena, sphalerite, tetrahedrite, enargite, chalcocite (stromeyerite), bornite, chalcopyrite, and pyrite. While the galena ore of the upper levels was argentiferous, the highest silver values occurred in connection with the copper-bearing minerals, especially the chalcocite, bornite, and chalcopyrite. These three ore minerals were almost invariably accompanied by pyrite. In the richer portions of the ore bodies the pyrite was subordinate, and appears to have been found chiefly in the peripheral portions of the stocks. But in the poorer ores the argentiferous copper minerals occurred as nodular bunches in masses of low-grade iron pyrite carrying up to 5 per cent of copper and a little silver, usually less than 10 ounces per ton, and a fraction of an ounce of gold. The pyrite usually forms a rather fine-grained and sometimes crumbling aggregate, but in the Zuñi mine occurs in beautifully sharp octahedra embedded in white kaolin. Bismuthiferous ores of silver and lead occurred in some of the ore bodies, notably in the Silver Bell and Genesee-Vanderbilt. Specimens from the latter mine contain a bright lead-gray mineral having the physical properties of cosalite, which chemical tests show to be slightly argentiferous sulphobismuthite of lead containing a little copper. Cosalite occurred also in the Yankee Girl. The rare mineral, kobellite, a sulphantimonite of lead with bismuth partly replacing the antimony, was found in the Silver Bell mine,[1] carrying from 3 to 4 per cent of silver. The only other known occurrence of this mineral is at Hvena, Sweden. The rich silver ores proustite and polybasite occurred in the Yankee Girl, Genesee-Vanderbilt, and probably other mines of this district. Tennantite is reported to have occurred in the National Belle mine. Zinkenite has been described by Hillebrand[2] from the Brobdignag claim, a now abandoned prospect in the Red Mountain Range near Chattanooga. Guitermanite and zunyite occur in the Zuñi ore body and in a few prospects close to the latter, the zunyite as small sparkling, colorless tetrahedrons embedded in the massive, bluish lead-gray guitermanite. Barite is apparently always present in the ores of the stock deposits. It often occurred as isolated crystals or crystalline masses embedded in the argentiferous bornite of the Guston and Yankee Girl mines, and these inclosed masses occasionally carried free gold. In the Zuñi it is intimately associated with pyrite and kaolin. The latter mineral is found associated with the ores of all the Red Mountain mines, sometimes occurring in the ore or serving as a matrix to pyrite, as in the Zuñi, but more abundantly in fissures in the wall rock and as a direct product of the alteration of the latter.

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[1] H. F. Keller: Zeitschrift für Krystallographie, Vol. XVII, 1890, pp. 67-72.

[2] Proc. Colo. Sci. Soc., Vol. I, 1883-84, p. 127.

Although the common structure of the principal ore bodies was that of a solid and massive aggregate, yet there is evidence that vugs or cavities sometimes occurred in the unoxidized ores. Stalactites of pyrite, having the radial structure usually considered as characteristic of marcasite, were seen, which were said to have come from caves in the Genesee-Vanderbilt. Specimens of enargite from the National Belle mine, preserved in various cabinets, show a free development of clusters of radial prisms of enargite, such as could only have formed in open spaces. The well-crystallized specimens of polybasite which have come from the Red Mountain district were also probably formed in vugs.

The large caves, however, such as were a feature in the upper workings of the National Belle mine, appear to have occurred above the ground-water surface. A few of the smaller of these caves only could be seen in 1899, and we are dependent upon the description of T. E. Schwarz[1] for knowledge of the occurrence of the oxidized or secondary ores. According to him, they occurred "above a former water line, either attached to walls of caves as broken detached masses, or as a bed of clayey mud or sand, more or less completely filling the cave." The ores are said to have been mainly "carbonates of lead and iron, with iron oxides, lead sulphate, and arsenates." Kaolinite and zinc blende were common, and galena occurred as residual kernels. "Such are the ores of the National Belle, Grand Prize, and Vanderbilt mines. Other mines omit lead minerals and carry oxide and sulphide of bismuth." Several hundred pounds of this metal are said to have been reduced in Durango. These caves are stated to have ramified through the knolls of silicified andesite, such as that described at the National Belle mine, which "are cut up by cross fractures." The following general conclusions are cited from Mr. Schwarz's paper:

1. The secondary ores are richer than the sulphide ores occurring below them.

2. The ores of adjoining or connecting caves are sometimes greatly different in grade.

3. In some cases the formation of the caves along fracture or cleavage planes is evident, but in others all traces of such planes are quite obliterated.

4. The cave walls are a porous sandy quartz (see description of

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[1] Trans. Am. Inst. Min. Eng., Vol. XVIII, 1890, pp. 139-145.

National Belle mine, p. 231), the sand from the disintegration of which forms part of the cave filling.

5. The line of change from oxidized to unoxidized ores, or the former water level, is very marked. It varies as much as 100 feet in elevation in properties within 1,000 feet of each other, rising to the south and west. The quartz outcrop rarely rises more than 200 feet above it.

6. In isolated cases may be found masses of the unoxidized ore, the enargite,[1] above the line of change, in the vicinity of the secondary ores.

Mr. Schwarz considered the caves and secondary ores to have been due to surface waters, which dissolved the sulphide ores and country rock as they moved along fracture planes. It appears unlikely, however, that the surface waters exercised much solvent action upon the country rock. Their function was probably limited to the oxidation of the ore and to the removal of some of its constituents.

CHANGES IN THE ORE WITH DEPTH.

As indicated in the preceding section, the ores of some of the stocks were partially oxidized down to the ground-water surface. This secondary alteration was particularly noticeable in the National Belle mine, and to some extent in the Vanderbilt mine, but was a much less conspicuous feature in the Yankee Girl, Guston, and other mines, the ore bodies of which outcropped nearer the bottom of the valley of Red Creek. The oxidation apparently presented no unusual features, and seems to have consisted chiefly of the transformation of galena to carbonate and sulphate of lead, with removal of more soluble constituents, reduction in the bulk of the ores, and the consequent formation of caves. Even when, as in the case of the National Belle, the ore of the deeper workings was chiefly enargite, the oxidized ores nearer the surface were evidently largely composed of lead compounds, as no reference is found to the occurrence of copper carbonates. This result is probably less a consequence of any peculiar process of oxidation than of the relative disposition of the sulphide or unoxidized ores prior to superficial weathering. It is with the changes in these latter ores relative to depth that this section has chiefly to do.

In spite of the diversity shown by the different ore bodies, there is after all remarkable uniformity to be found in the change at very moderate depths—usually less than 300 feet—from an ore consisting chiefly of argentiferous galena to highly argentiferous silver-copper ores, and then a gradual diminution of value downward through the increasing proportion of low-grade pyrite in the ore bodies. These changes are best recorded in the Yankee Girl, Guston, and Silver Bell mines. There are certain exceptions to what may be regarded as the normal or complete sequence. Thus the Congress mine appears to have had an ore consisting chiefly of enargite, with some bunches of galena, from the croppings downward. That the enargite at greater depth will gradually give place to iron pyrite, with diminishing amounts of chalcopyrite, can scarcely be doubted in the light of what is known of other deposits of this district. In the National Belle, enargite—in this case low grade—was encountered near the surface, but the oxidized ore in the siliceous knoll which forms the croppings appears to have been derived chiefly from galena, while below the third level (fig. 20) practically no pay ore was found. Explorations on the fourth level resulted only in the finding of small bunches of good ore and masses of crumbling iron pyrite carrying less than 0.1 ounce of gold and about 5 ounces of silver per ton, with from 1 to 3 per cent of copper.

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[1] It is evident that in this description Mr. Schwarz has the National Belle deposit most in mind.

Chalcopyrite appears to have been usually good ore. It carries, theoretically, 34.5 per cent of copper, and in the Red Mountain district ran well in silver and gold; but its appearance in great quantity was apparently a precursor of the ultimate change to ores carrying chiefly the low-grade iron pyrite.

Although there was on the whole a general change from argentiferous lead ores to argentiferous and auriferous copper ores, and finally to slightly argentiferous and auriferous iron sulphide (pyrite), yet the progression was an overlapping and irregular one in detail. Iron pyrite and chalcopyrite occurred at practically all depths, while galena in small bunches was sometimes found far below the point at which it had ceased to be the principal ore.

VALUE OF THE ORES.

The ores of the stocks, like those of the lodes, vary widely in value. In 1883, 3,000 tons of ore extracted from the Yankee Girl averaged nearly $150 per ton. A lot of 10 tons from the richest stopes of the same mine carried 3,270 ounces of silver per ton and 29 per cent of copper, corresponding to an average value per ton of about $3,000. Much richer ore than this occurred in small quantities in the Yankee Girl and Guston. The average sales value per ton of the ore of the latter mine has been given in the table on p. 222 as $91.81 for a period of eight years. The highest annual average was $363.25 per ton, and the lowest $10.70. These, it should be borne in mind, are the prices for which the ore was actually sold to the smelters. Values based directly upon metallic contents, without reference to cost of treatment, would be higher. The highest annual average represents the ore from the rich stopes above the seventh level. The lowest corresponds to the low-grade pyritic ore of the deeper levels. The richest ore recorded from this district was some taken in 1891 from the Guston at a depth of 378 feet, which carried 15,000 ounces of silver and

3 ounces of gold per ton, worth, at the then current price of silver, $14,880.

The ore of the Genesee-Vanderbilt was of much lower grade than that of the Yankee Girl, Guston, and Silver Bell. Its gross value for any one year probably never averaged more than $40 per ton. No records, however, are available for the ore taken out prior to 1893, when the price of silver stood higher. The ore of the National Belle was also low grade, but its average value is not known.

MINERAL WATERS ASSOCIATED WITH THE ORE DEPOSITS.

Probably all the waters met with in the mines of the Silverton quadrangle now accessible are meteoric waters variously modified by the materials though which they have passed in their more or less direct descent from the surface. The abundance of these waters varies much in different mines, and fluctuates with the seasons. In the Gold King mine scarcely a drop of water reaches the lower levels. Many other mines, such as the Silver Peak and Iowa, which are moderately wet in summer, become nearly dry in winter, owing to the freezing of the ground near the surface. In no case was any noticeable spring or ascending mineralized water encountered in the ore deposits now being worked. The descent of the meteoric water through masses of pyrite and other ore minerals is, however, often sufficient to give it a strong acid reaction and render it highly ferruginous.

In the Red Mountain district the troublesome acid character of the mine waters was notorious. In spite of their strong mineral nature and abundance, however, it is not improbable that these, too, were meteoric waters which had become strongly charged with sulphuric acid by their oxidizing passage through the adjacent bodies of pyrite and through the masses of altered pyritized country rock which surround the latter.

Strongly ferruginous springs are abundant within the drainage of Cement Creek and in the upper basin of Red Creek. As their waters are brought in contact with the atmosphere the iron in solution is oxidized and deposited near the spring as a mound or apron of limonite, or accumulates as bog iron in the swampy ground along these creeks. Such springs, with there accompanying deposits, may be well seen near Burro Bridge, also just below Chattanooga, and near the village of Red Mountain. A spring of the same general character issues from the hillside about 150 feet above the Guston mine, and has deposited a large apron of limonite. At present the water issues from a tunnel which was run into the limonite mass, and has cemented the dump of the tunnel into a firm, ferruginous mass. Some of this water was collected for analysis. As it issues from the tunnel it is clear, moderately cold, and noneffervescing, and has an astringent acid taste. When received in the laboratory at Washington the water gave a strongly acid reaction, and a deposit of ferric hydroxide or basic ferric sulphate, together with some silica, had settled in the bottom of the bottle. The total contents of sample were subjected to partial qualitative tests by Dr. Hillebrand, with the following results:

Partial analysis of water from spring above the Guston mine.

Constituent.	Remarks.	Constituent.	Remarks.
SO_3	Very much.	Zn	A little.
Cl	Very little.	Mn	Not tested for.
Al_2O_3	Much, about 214 parts per million.	Ni	
		Co	
Fe	Much.	Cu	0.65 parts per million.
Ca	Do.	Pb	Absent.
Na	Not tested for.	Mo	
K	Do.	As	
SiO_2	About 75-80 parts per million.	Ag	
		P_2O_5	Not tested for.

It appeared from these preliminary tests that the water of this spring carried no appreciable amounts of the important ore-forming metals, and it was not considered advisable to devote time and labor to further chemical work upon it. It was at first hoped that its analysis might throw some light upon the nature of the solutions which originally deposited the Red Mountain ores. But the preliminary tests indicate no characters that might not be expected in ordinary meteoric waters after passing for some distance through the mineralized and altered rocks of the immediate vicinity. There is, so far as known, no definite evidence connecting the ferruginous springs of this region directly with the original processes of ore deposition, nor is it necessary to assume that the waters issuing from them have come from deep-seated sources. The mine waters of the Yankee Girl and Guston are said to have carried much copper in acid solution. This is to be expected wherever surface waters carrying oxygen pass downward for any distance through pyrite and chalcopyrite. The presence of considerable alumina has an important bearing on the question of the metasomatic alteration of the country rock, as will be later shown.

METAMORPHISM OF THE COUNTRY ROCK IN CONNECTION WITH ORE DEPOSITION.

The metamorphism or change which has been effected through the agency of the mineral-bearing solutions (hydrothermal metamorphism) in the rocks adjacent to the ore bodies differs very markedly in degree, and to a less extent in character, in different portions of the quadrangle.

The mode of alteration is in general by *metasomatism* (literally *change of* body), by which is meant the process by which a mineral, through chemical reactions, undergoes a partial or complete change in its chemical constitution. Rocks or aggregates of minerals are "metasomatic" if any or all of the constituent minerals have undergone such changes.[1]

In Silver Lake Basin the simple fissure veins which there predominate, carrying galena, sphalerite, chalcopyrite, pyrite, and sometimes tetrahedrite, in a gangue of quartz with frequently some barite, are not accompanied by any very evident or striking alteration of the immediate wall rock.

As elsewhere pointed out, the rocks of Silver Lake Basin belong to the Silverton series. No attempt will be made in this report to give the petrographical characteristics of the series as a whole (for which the reader is referred to the forthcoming report of Mr. Whitman Cross); it is enough to say that the prevailing rock of the basin, and the one which constitutes the greater part of the country rock met with in the workings of the Silver Lake and Iowa mines, is a firmly consolidated, homogeneous, andesitic breccia. This differs from the older San Juan breccia in its greater homogeneity and in the frequent occurrence of more or less orthoclase. Indeed, it is not unlikely that the whole should be referred rather to the latites than to the andesites proper. With the breccia are associated massive andesites and latites. The breccia is in general somewhat altered, even when not close to an ore-bearing lode, a result that is to be expected when the thorough fissuring which the rocks have undergone and the extent to which they must have been permeated by ore-bearing solutions are taken into account.

A specimen of this rock taken on the trail from Arrastra Gulch up to the basin, at an elevation of about 11,800 feet, may be regarded as representative of the relatively unaltered facies. It is a tough, greenish-gray rock with pale lilac-gray mottlings, and, although showing a few feldspar phenocrysts, is generally of rather compact texture. The breccia structure, not very apparent on fresh fracture, owing to the homogeneity of the component fragments, becomes visible when the rock is breathed upon or has been slightly weathered. Under the microscope its clastic structure is evident. Fragments of general andesitic character lie in the matrix of fine andesitic detritus, which is not always easily separable from the larger fragments. This clastic matrix contains broken phenocrysts of andesine or labradorite, and an occasional somewhat rounded grain of quartz, in a fine feldspathic and obscure groundmass. There is some magnetite present, but ferromagnesian constituents are lacking. If formerly present, they have been destroyed by secondary alteration. The feldspars are largely changed to sericite (with perhaps some kaolinite) and to calcite, while bunches of calcite and flecks of chlorite are thickly disseminated through the rock. Some epidote is frequently present, although not seen in this particular slide. Such of the massive andesites and latites as were examined in thin section show a similar development of secondary chlorite, calcite, and sericite, indicating an alteration that is essentially propylitic in character.

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[1] Lindgren; Trans. Am. Inst. Min. Eng., Vol. XXX, 1900, p. 580.

Within the Silver Lake and Iowa mines the amount of alteration in the country rock which can properly be referred to the action of ore-bearing solutions moving along any given fissure is slight. The breccia usually preserves its greenish color and general appearance close up to the fissure walls. In the Iowa mine specimens were taken in the main crosscut on the fourth level at various distances from the Iowa vein, for the purpose of studying the alteration of the country rock dependent upon the formation of this lode. All of these specimens are pale greenish-gray rocks of one kind—a breccia of the type already described.

At points 150 feet east of the lode the country rock is fine grained and faintly mottled, showing only a few pale, minute phenocrysts of feldspar and an occasional tiny grain of quartz. Under the microscope the rock reveals the character of a much-altered andesitic tuff or fine breccia. The feldspars have been completely altered to aggregates of sericite and calcite, while areas of calcite and chlorite probably represent former phenocrysts of augite. The groundmass is a rather indistinct aggregate of secondary quartz, sericite, and chlorite, with a little apatite and rutile. The rock is thus practically wholly recrystallized into a secondary aggregate while retaining the grosser structure of the original.

At a distance of 100 feet from the vein the country rock is megascopically like that just described. Under the microscope it shows less alteration than the preceding. Chlorite and calcite are abundant, but much of the plagioclase is still recognizable. Sericite and quartz are not such prominent constituents as in the other rock.

At places 50 feet from the vein the country rock is still of the same general appearance as that already described. In thin section under the microscope it shows a general andesitic structure, but is almost wholly recrystallized. The feldspar phenocrysts have been changed to aggregates of calcite and sericite, while areas of chlorite and calcite, with sometimes rutile, are all that remain of the phenocrysts of augite or biotite. The groundmass, also, while preserving the outlines and in small part the substance of former lath-shaped feldspars, is now an aggregate consisting chiefly of quartz, chlorite, sericite, and a little rutile and apatite. The thin section does not show clastic structure, and is probably from a fragment in the breccia.

At a distance of 2 feet from the vein the only megascopical change in the country rock consists of the presence of an occasional speck of galena. Rather curiously, finely disseminated pyrite, which is a common feature of most country rock near a productive lode, does not in *this case* accompany the galena as a megascopical constituent. Under the microscope it is seen that the alteration has been more thorough than in the specimens previously studied. The forms of some of the phenocrysts are preserved by pseudomorphous aggregates—sericite, with some chlorite, calcite, and rutile, apparently after biotite, and calcite, quartz, sericite, and chlorite in varying proportions after augite and plagioclase. The groundmass is entirely recrystallized as a fine aggregate composed chiefly of quartz and sericite, with less chlorite. Occasional larger grains of quartz with rounded and embayed outlines are probably original phenocrysts. A little apatite and a few minute grains of pyrite occur in the groundmass. The dominant minerals of the rock are quartz and sericite. A specimen taken from the same crosscut at a distance of only 10 inches from the west wall of the vein resembles the others closely. It does not, however, show breccia structure, and is sparingly sprinkled with small crystals of pyrite. Under the microscope the rock is seen to be essentially an aggregate of sericite, quartz, calcite, and chlorite, named in the order of relative abundance. The former feldspar phenocrysts are now pseudomorphs of sericite, calcite, and quartz, and biotite has been altered to chlorite, sericite, and rutile. The groundmass consists chiefly of quartz, chlorite, calcite, and sericite. Although this facies is nearer the vein than the preceding, the character of its metamorphism is perhaps even less differentiated from the more general kind of propylitic alteration which the country rock in the mine, even at a distance of several hundred feet from the principal lodes, has undergone. Lastly, a specimen was taken from the east wall of the Iowa vein in the main stope above the fourth level. At this point the vein contained good ore, and the absence of gouge allowed the specimen to be taken immediately in contact with the ore. It differs from those thus far described in its light-gray color and more evident alteration. It is sprinkled with pyrite and a little galena, and is traversed by minute veinlets of quartz. Its breccia structure is still discernible in the hand specimen. Microscopically examined, the rock, while retaining traces of clastic origin, is wholly recrystallized. The former phenocrysts of feldspar are replaced by pseudomorphous aggregates of quartz and sericite. The quartz in such cases is often rather coarsely crystalline (grains up to 0.5 millimeter in diameter), the sericite being included as minute wisps, or gathered into bunches in the interstices between the allotriomorphic quartz grains. Crystals of pyrite are sometimes inclosed in the quartz. Of augite no trace remains, but some sericite inclosing rutile is apparently pseudomorphous after biotite. The groundmass is a finely crystalline mosaic of quartz and sericite. The notable feature of this wall rock is the absence of calcite and chlorite.

The alteration studied in the foregoing set of specimens, collected for that purpose in the Iowa mine, has been traced with similar results in collections from the neighboring Silver Lake mine. Calcite and chlorite are as a rule prominent constituents of the altered country rock to within a few inches of the productive lodes. Frequently, but not always, the rock in contact with the ore, or occurring as small horses in the veins, is free from chlorite and calcite and consists mainly of quartz and sericite, with some disseminated ore minerals. The latter, however, are not limited to the immediate walls of the fissure, but specks of galena and crystals of pyrite may occur 25 feet or more from the nearest lode, in rock carrying much calcite and chlorite. As an example of the extreme alteration which the country rock has undergone in the formation of these ore bodies may be described a specimen from the third level of the Silver Lake mine, taken from the wedge of country rock between the Stelzner and Royal veins at their junction. The usual breccia is here bleached almost white, and shows a fine, even-granular texture to the naked eye, but as a whole is shattered, full of quartz stringers, and contains flakes of galena. Under the microscope, pseudomorphs of sericite after feldspar and biotite preserve the only remnants of original structure. The groundmass is a very finely crystalline aggregate of quartz and sericite traversed by microscopic quartz veinlets. As usual, there is a little rutile present, and some crystals of pyrite.

To sum up briefly, the rocks in which the ore deposits of Silver Lake Basin occur are chiefly andesitic or latitic breccias. In the neighborhood of the mines these breccias have been generally altered to an unknown depth. The alteration involves the change of feldspar to sericite, calcite, and quartz; of augite to calcite and chlorite; and of biotite to chlorite, sericite, and rutile. Although this metamorphism is probably connected with the ore deposition, it is so generally prevalent that it can not in any case be recognized as being connected with the deposition of ore in any given fissure. It appears to have been effected through the agency of water charged with carbon dioxide or carbonates. The change involved in the rocks is propylitic in nature, and, as Lindgren[1] justly maintains, should be distinguished from ordinary weathering, with which it is often confused. Close to the veins, usually within a few inches, and in small horses of country rock within the veins, metamorphism of a different kind frequently occurs. Here calcite and chlorite have diminished in amount or are wholly absent, and quartz and sericite constitute the bulk of the rock. This alteration, which plainly emanates from the individual fissure, differs from the more general metamorphism less in kind than in the relative proportions of calcite and chlorite on the one side and of quartz and sericite on the other. This usually inconspicuous and very local alteration of the wall rock to quartz and sericite is rather common within the quadrangle, especially near lodes in the andesitic rocks of the Silverton or San Juan series. It occurs in somewhat pronounced degree in the Ridgway mine, which produces an argentite ore. It is the usual alteration seen in the mines of Savage Basin, Sultan Mountain (in monzonite), and in many other lodes where metamorphism of the country rock other than that of propylitic nature is not a conspicuous phenomenon, and where no special microscopical study of wall rock was made.

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[1] Metasomatic processes in fissure veins: Trans. Am. Inst. Min. Eng., Vol. XXX, 1900, p. 645.

The alteration of the country rock in Silver Lake Basin may be accounted for on the assumption that the solutions which filled the fissures contained alkaline carbonates. But that the alkaline carbonates were present in small amount seems to be indicated by the uniform presence of chlorite (except in the actual walls of the vein, where it as well as calcite may be absent); for, as Lindgren[1] has pointed out, it is probable that chlorite can not exist under the action of strong solutions of alkaline carbonates. The immediate wall rock of the fissures, being more exposed to the action of solutions, has in most cases suffered the removal or further alteration of the chlorite and carbonates which were probably first formed. Connected with this later stage is the accumulation of the insoluble sericite, derived from labradorite, biotite, and probably other minerals, and very likely the direct addition of quartz in place of the removed calcite. Although no chemical analyses have been made of these wall rocks, it is probable that the abundance of sericite (derived in great part from lime-soda feldspars), which is common in the rock in contact with the vein filling, indicates a direct addition of potash to the substance of the rock, as was found by Lindgren[2] to be the case in the Grass Valley and Nevada City veins. Kaolinite was not certainly identified in the altered wall rocks of Silver Lake Basin, but in the Dives mine (on the North Star lode) it apparently occurs with sericite and quartz, as seen in an altered andesitic horse in the lode. Metamorphism in connection with the Dives ore body is similar to that just described in detail for the Silver Lake mines; but in its greater intensity, in the presence of kaolinite, and in the more evident silicification of portions of the wall rock it is intermediate in character between that metamorphism and the kind next to be described.

Of a somewhat different kind from that which has just been discussed is the metamorphism observed in connection with the ore deposits of Engineer Mountain and of the Red Mountain district. As the ore of Engineer Mountain occurs in lodes, while that of the Red Mountain district is prevailingly in stocks, and as the metamorphism presents some phases of difference in the two modes of occurrence, they will be separately treated.

The Polar Star lode, which has produced some rich silver ore carrying argentite and proustite, may be considered as a type of the Engineer Mountain deposits. Unfortunately, its workings are no longer accessible, but the metamorphic processes connected with ore deposition may be studied to considerable advantage from surface exposures and the material of the dumps. The country rock of the Polar Star is a dark-gray rock of andesitic appearance, carrying abundant glistening phenocrysts of plagioclase up to 7 or 8 millimeters in length. In thin section, under the microscope, the plagioclase is seen to be chiefly labradorite (ab_1 an_1) which is almost perfectly fresh. Phenocrysts of a pale augite or diopside are almost wholly altered to calcite and chlorite, and some bastite pseudomorphs indicate the former presence of phenocrysts of an orthorhombic pyroxene. Quartz, and probably some orthoclase, are present in the groundmass. The chemical analysis of this rock is given in Column I, page 122. This analysis differs from that of a normal andesite in its rather high alkalies and relatively high potash. It might be classed as a latite. Owing to its somewhat weathered condition and lack of knowledge as to the accurate chemical constituents of the resulting chloritic and serpentinous products, an attempt to calculate the mineralogical composition from a chemical and microscopical analysis is not entirely satisfactory.

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[1] Trans. Am. Inst. Min. Eng., Vol XXX, 1900, p. 610.

[2] The gold-quartz veins of Nevada City, etc.: Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. II, 1896, p. 148.

Calculating the carbon dioxide as calcite, the soda as labradorite (ab_1 an_1), the phosphoric anhydride as apatite, the residual lime as diopside, all the potash as orthoclase, and dividing up the other constituents between chlorite, serpentine, magnetite, etc., the following approximate mineralogical composition was obtained.

Mineralogical composition of andesitic rock (latite?) from Engineer Mountain.

Constituent.	Per cent, by weight.	Constituent.	Per cent, by weight.
Labradorite (ab_1an_1)	33.9	Kaolinite	2.6
Orthoclase (?)	22.4	Magnetite	2.3
Quartz	14	Hematite	3.8
Diopside ($CaMg(SiO_3)_2$)	4.7	Apatite	1
Chlorite ($H_{40}(FeMg)_{23}Al_{14}Si_{13}O_{90}$)	7	Rutile and leucoxene	1.4
Calcite	3		98.9
Serpentine	2.8		

There still remains about 1 per cent of alumina not accounted for in the above calculation. Combined with part of the ferrous iron here calculated as magnetite and chlorite, and with some of the silica, reckoned as quartz, it may enter into the composition of the pyroxene, which probably does not correspond exactly to the theoretical diopside molecule. The percentage of kaolinite is rather higher than the microscopical investigation would indicate. The specific gravity as calculated from the foregoing mineralogical composition, ignoring porosity, is about 2.8. The foregoing specimen was taken a few hundred feet west of the mine, and, although fresher rock occurs in the vicinity, this was selected for chemical analysis as being undoubtedly the particular facies in which the Polar Star lode was formed.

The dumps of the Polar Star mine are made up largely of a locally altered form of the foregoing latite. The original porphyritic structure is perfectly preserved, but the rock is bleached to a very light-gray tint, and the feldspars are completely kaolinized. Small crystals of pyrite are abundant, occurring both in the altered phenocrysts and in the groundmass. This is evidently the country rock which immediately incloses the ore, although it is not known how far this pronounced alteration extended on either side of the ore-bearing fissure zone. Under the microscope the rock appears as a fine-granular aggregate, consisting chiefly of quartz, kaolin, and diaspore, with considerable disseminated pyrite. The porphyritic structure is partially lost between crossed nicols, although the abundance of diaspore in some of the altered phenocrysts differentiates them from the groundmass. The diaspore occurs in irregular grains up to about 0.5 millimeter in diameter. The relatively high refractive index, strong double refraction with consequent brilliant polarization colors, and the conspicuous cleavage render the mineral very noticeable in thin section. It is biaxial, with dispersion red less than blue.

In order to confirm the microscopical determination, a portion of the rock was powdered and treated with hydrofluoric acid by Dr. Hillebrand. The resulting residue proved, on microscopical examination, to consist of grains of the supposed diaspore, with a few particles of pyrite and a little amorphous material. A rough quantitative analysis showed that the residue consisted of about 84.4 per cent of alumina and 15.2 per cent of water, thus placing the identification of the mineral as diaspore beyond question.

A chemical analysis of this altered rock is given in Column II on page 122. The two analyses of fresh and altered rock, as they stand side by side, represent a comparison of unit weights, and therefore are not, in all probability, directly comparable for the purpose of ascertaining the actual change that has taken place in a unit volume of the original rock. It may, however, be tentatively assumed that the alumina has remained constant. An analysis of the altered rock recalculated on this basis gives the result shown in Column II*a*. A comparison between Column II*a* and Column I shows that, under the assumption made, the altered rock has suffered a total loss of substance of over 14 per cent. A little silica, 3.15 per cent of water, and some sulphur have been introduced, while magnesia and carbon dioxide have been wholly, and lime-soda potash almost entirely, removed. Of the original iron present in the rock, a little more than one-half remains combined with sulphur to form pyrite. It will be noted that in the recalculated analysis the phosphoric and titanic acids are very nearly the same as in the fresh rock, which lends some support to the assumption previously made that the alumina has remained practically constant in the process of metamorphism. It seems at first sight probable that the loss of substance in the altered rock may be accompanied by an increase of porosity without actual shrinkage of the rock as a whole. If this be so, the specific gravities of the unaltered and altered rock, as determined on considerable fragments, should be to each other approximately as 100 is to 86 (i. e., to 100 less the loss of substance due to metamorphism). The specific gravities as actually determined are 2.764 and 2.734, and their ratio is as 100 to 99. This result does not accord with the idea that the loss of substance has resulted in corresponding increase of porosity with retention of initial volume. In so far as the laboratory determinations of specific gravity may be relied upon in drawing conclusions as to the mass as a whole, they indicate that the loss of substance has been followed by diminution of volume, presumably associated with actual cracking or fissuring and not with increased porosity.

Analyses and recalculations of rocks of Polar Star mine, Engineer Mountain.

Constituent.	I.	II.	IIa.	Loss or gain of each constituent in percentage of the whole original rock.	IIb.	Loss or gain of each constituent in percentage of the whole original rock.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
SiO_2	55.61	64.79	56.13	+0.52	64.14	+8.53
Al_2O_3	16.40	18.93	16.40	0	18.74	+2.34
Fe_2O_3	5.44	None.	None.	−5.44	None.	−5.44
FeO	2.37	None.	None.	−2.37	None.	−2.37
MgO	3.25	None.	None.	−3.25	None.	−3.25
CaO	5.85	.43	.37	−5.48	.42	−5.43
Na_2O	2.61	.15	.13	−2.48	.14	−2.47
K_2O	3.77	.24	.20	−3.57	.23	−3.54
H_2O-	.46	.50	.43	− .03	.49	− .06
H_2O+	1.51	5.39	4.66	−3.15	5.33	3.82
TiO_2	1.10	1.21	1.04	− .06	1.19	− .09
CO_2	1.33	None.	....	−1.33	....	−1.33
P_2O_5	.45	.51	.44	− .01	.50	− .05
S	Trace.	....	....	....	....	....
Cr_2O_3	None.	None.	....	....	....	....
NiO	None.	None.	....	....	....	....
MnO	.09	None.	....	− .09	....	− .09
BaO	.03	.06	.05	+ .02	.06	+ .03
SrO	.05	Trace.	....	− .05	....	− .05
Li_2O	Trace.	Str. tr.	....	....	....	....
FeS_2	....	7.19	....	+6.22	7.12	+7.12
Total	100.32	99.40	....	−14.25		−1.96
Sp. gr	2.764	2.734 at 19° C. (W. F. Hillebrand.)				

I. Latite. Country rock of the Polar Star mine, Engineer Mountain. Analysis by H. N. Stokes.

II. Metasomatically altered latite. Wall rock of Polar Star mine, Engineer Mountain. Analysis by H. N. Stokes.

IIa. Recalculation of II on basis of constant alumina.

IIb. Recalculation of II on basis of constant volume.

It will be remembered that the preceding discussion rests upon the initial assumption that the alumina has remained constant during the metamorphism. This assumption may not be correct, and it will further the inquiry, as well as illustrate the complexity of the problem, to trace the results growing out of another probable premise. If it be assumed that during the metamorphic processes the volume of any given mass of the rock has remained constant, then the analysis of the altered rock may be recalculated on this basis, using for this purpose the determined specific gravities, and be then compared with that of the unaltered rock. The result of this comparison is shown in Column II*b*

It appears from this total that under the assumption of constant volume the rock has lost only about 2 per cent of its substance through metasomatism. Moreover, there has been an addition of 8.5 per cent of silica and 2.3 per cent of alumina. In other respects the alteration is not significantly different from that deduced upon the hypothesis of constant alumina.

It is, of course, possible that neither the hypothesis of constant alumina nor that of constant volume is strictly true; but it is believed that the latter is a closer approximation to the truth than the former. The altered rock is not notably porous, nor does it, in the field, show evidence of contraction in bulk. Moreover, the very obvious introduction of quartz into some facies of it and the occurrence of diaspore point to that assumption involving the introduction of silica and alumina as being nearest the truth.

In order to further test this point a special examination was made of the spring water issuing above the Guston mine (see p. 114) to determine whether it carried alumina in solution. It was found to be present to the extent of about 214 parts per million, thus proving that the alumina in the rocks can not be regarded as a constant constituent during metasomatic alteration in this region.

The mineralogical composition of the altered rock may be roughly calculated from Analysis II as follows, the soda being considered as accompanying the potash in sericite:

Mineralogical composition of metasomatically altered wall rock of Polar Star mine, Engineer Mountain.

Mineral.	Percentage by weight.	Mineral.	Percentage by weight.
Quartz	48.8	Rutile	1.2
Kaolinite	30.3	Apatite	.7
Diaspore	6.6		
Pyrite	7.2		98.7
Sericite	3.9		

The specific gravity of the rock, as derived from the foregoing mineral composition and excluding pore spaces, is about 2.9, as compared with 2.8 similarly obtained for the unaltered rock. This rough calculation is thus in agreement with the general rule that near fissure veins the replacing minerals are as a whole denser than those replaced.[1]

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[1] Lindgren: Trans. Am. Inst. Min. Eng., Vol. XXX, 1900, p. 594.

Although the altered facies just described appears to indicate only slight silicification or actual addition of silica to the rock, this process has taken place to a greater extent in the immediate walls of the fissures and in fragments of country rock included within the vein quartz. Such facies show little or no diaspore, but more sericite. The secondary quartz in such rocks is often more coarsely granular, and in thin section can be distinguished from the quartz which fills veinlets only through its association with nests of sericite, kaolinite, and a little diaspore. All original structure of the latite disappears between crossed nicols.

Summing up briefly, the characteristic features of the Polar Star metamorphism are (1) its restriction to the immediate vicinity of the lode, (2) the removal of at least 2 per cent of the substance of the rock, including all of the magnesia and carbon dioxide, nearly all of the alkalies and lime, and much of the iron, (3) the addition of silica, water, alumina, and sulphur, and (4) the formation of a secondary aggregate chiefly of quartz, kaolinite, pyrite, diaspore, and sericite.

The depth to which the alteration of the character extends is not known. The specimens studied evidently came from the deepest workings, probably over 500 feet from the surface.

It is not probable that the metamorphism described can have been effected by solutions in which alkaline carbonates were the principal constituents. It is more likely that the effective agent was acid water. If, however, the water contained sulphuric or hydrochloric acids it is, at first thought, rather difficult to understand the formation of kaolinite and diaspore. But as these minerals themselves are not soluble in acids, they may be capable of forming, under certain conditions, even in the presence of such a solvent for alumina as free sulphuric acid. Acid waters containing sulphuric acid circulate through the rocks of the Red Mountain region at the present day and have not prevented the formation of kaolinite nor effected its removal. In fact, they have probably in some cases aided directly in its formation by serving as solvents from which the alumina has been precipitated as kaolinite or diaspore under favorable conditions. The formation of diaspore instead of kaolinite in the presence of abundant silica indicates a very moderate hydration.

The metasomatic alteration of the rocks of the Red Mountain Range has frequently been referred to in this report. It is not limited to the immediate vicinity of known ore bodies, but is so widespread and noticeable a feature as to become an important problem in the general geology of the region and a serious embarrassment to the geologist intent upon unraveling the structure and relationships of the various igneous rocks involved.

As a rule, the metamorphosed rocks, where not superficially stained by iron oxide, are nearly white. Frequently traces of original structure, such as outlines of feldspar phenocrysts or of breccia fragments.

can be recognized, but not uncommonly these, too, have vanished, and the rock has become a white granular aggregate resembling a fine-grained quartzite. Of such origin and character is most of the so-called "quartz" of the Red Mountain mines, which forms the siliceous knobs in which many of the ore bodies outcrop.

The mound at the White Cloud mine may be taken as a typical example of such a knob or knoll. It is elliptical in plan and about 50 feet long, trending N. 10° E. It rises about 30 or 40 feet above the general slope of the hill, and is composed of bleached siliceous rock which occasionally shows traces of breccia structure and which is evidently an altered form of the Silverton andesitic breccia. It contains considerable very finely disseminated pyrite.

A thin section of this rock shows a finely crystalline, rather turbid aggregate of quartz, kaolin, pyrite, rutile, and some minute indeterminable minerals. Some outlines of former phenocrysts are recognizable in ordinary light, but these disappear between crossed nicols. The quartz grains are very irregular in outline and intricately interlocked. They are full of minute inclusions of kaolinite, rutile, pyrite, and other minerals too small for determination. The kaolin occurs in bunches showing the characteristic foliated aggregation of the individual scales, and the usual low double refraction.

A chemical analysis of this rock, from a specimen taken in a short tunnel in the knoll, is here given:

Analysis of altered andesitic breccia from White Cloud mine.

[George Steiger, analyst.]

Constituent.	Per cent.	Constituent.	Per cent.
SiO_2	85.49	TiO_2	.63
Al_2O_3	5.49	CO_2	None.
Fe_2O_3	.23	P_2O_5	.07
FeO	.25	SO_3	.46
MgO	None.	MnO	None.
CaO	.27	BaO	.07
Na_2O	None.	FeS_2	3.43
K_2O	None.		99.92
H_2O-	.46		
H_2O+	3.07		

No analysis of unaltered rock is here available for comparison, and it is not possible to determine accurately the additions and subtractions to the original rock which have resulted in the metamorphosed facies. It is evident, however, that either the alumina has been very greatly reduced or the silica has been enormously increased. In all probability there has been some removal of alumina and a large addition of silica. Ferric and ferrous iron have been partly removed and the residue has been changed to pyrite. Lime has been almost all carried away and soda and potash have been wholly removed. Carbon dioxide is absent. The little sulphuric anhydride present is probably combined with baryta as barite.

The mineralogical composition of the altered rock may be roughly calculated as follows:

Mineralogical composition of altered andesitic breccia from White Cloud mine.

Mineral.	Per cent.
Quartz	78.5
Kaolin	12.8
Pyrite	2.4
Rutile	.6
	94.3

About 1 per cent of water is not accounted for, as there are no alkalies or alumina to combine with it. It may exist as chalcedony or opal, or as some hydrated compound of iron. No attempt has been made to calculate the small amounts of ferric and ferrous iron, lime, phosphoric acid, sulphuric acid, and baryta, which probably correspond to a little barite, apatite, and other minerals present in minute quantities in the rock. The total absence of sericite is rather remarkable. The character of the alteration points to acid waters as the cause of metamorphism.

Of the same general character as the foregoing is the metamorphism which has transformed andesitic tuffs or breccias of the Silverton series into the highly siliceous rock forming the greater part of the picturesque knob in which the National Belle mine lies, at the village of Red Mountain. The resulting rock is nearly white and decidedly porous. Examined with a lens, it appears to consist wholly of quartz with a little pyrite, and is full of minute cavities sparkling with quartz crystals. Locally this porous structure may be so pronounced as to give the rock a pumiceous appearance.

Under the microscope, in ordinary light, the remnants of porphyritic structure are easily recognizable. Relatively clear areas having the shape of feldspar phenocrysts and dark areas containing much finely divided pyrite and other opaque particles, clearly pseudomorphs after some phenocrysts—probably ferromagnesian constituents—lie in a groundmass somewhat turbid with minute dark particles. With the nicols crossed, however, this structure practically vanishes, and the whole appears as a finely crystalline granular aggregate of quartz. The space formerly occupied by the phenocrysts of feldspar is now filled with quartz, somewhat more coarsely crystalline than in the groundmass. Frequently the quartz does not quite fill the space, but has left a microscopic vug in the center. The quartz making up the rock is not pure, being crowded with indeterminable inclusions. But the rock in all probability contains over 90 per cent of silica, and the evidence of thorough silicification, with removal of nearly all of the bases save a little iron to form pyrite, is unquestionable. It shows that under certain conditions even the alumina may be removed, and that the assumption as to the constancy of this constituent in unaltered and altered rock must be used with caution.

An intrusive porphyry, belonging with the monzonite-latite group of rocks, is fairly abundant in the Red Mountain region, where it forms relatively small masses of circular or elliptical plan. It has been intruded in the form of plugs or bosses into the volcanic rocks, and, like the latter, has undergone metasomatic alteration. Where not greatly altered—as, for example, at an exposure by the roadside a few hundred yards south of the Yankee Girl mine—the rock is conspicuously porphyritic, showing phenocrysts of pink orthoclase up to three-quarters of an inch in length, smaller crystals of white plagioclase, and anhedrons (crystalline grains) of quartz, all lying in a compact, greenish-gray groundmass.

Under the microscope the rock shows considerable decomposition. The orthoclase is fairly fresh, but the plagioclase (apparently in part acid oligoclase) is partly sericitized. Areas of calcite and chlorite with a little pyrite are apparently pseudomorphous after augite or diopside. The groundmass is a rather cloudy, fine-granular aggregate which seems to consist chiefly of quartz and orthoclase, but contains considerable calcite and chlorite, with some apatite, a good deal of finely disseminated pyrite, and some titanic iron altering to leucoxene. A chemical analysis of this rock is given in Column I in the following table:

Analyses of monzonitic porphyry.

[H. N. Stokes, analyst.]

Constituent.	I.	II.	Constituent.	I.	II.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
SiO_2	58.78	73.61	P_2O_5	.53	.33
Al_2O_3	13.62	13.97	SO_3	....	Not det.
Fe_2O_3	1.70	None.	Cr_2O_3	None.	None.
FeO	2.27	None.	NiO	None.	None.
MgO	3.29	None.	MnO	Trace.	Trace.
CaO	4.31	.31	BaO	.12	.04
Na_2O	3.24	.04	SrO	.05	Trace.
K_2O	4.06	.06	Li_2O	Trace.	Strong tr.
H_2O-	.25	.58	FeS_2	1.56	5.62
H_2O+	1.57	4.18		99.73	99.34
TiO_2	.99	.60			
CO_2	3.49	None.			

I. Monzonitic porphyry, from near Yankee Girl mine.
II. Metasomatically altered facies of foregoing, from near National Belle mine.

From this analysis and the microscopical study the mineralogical composition may be calculated as follows:

Mineralogical composition of monzonite-porphyry.

Constituent.	Per cent.	Constituent.	Per cent.
Albite (molecule)	27.4	Titanic iron ore Magnetite and rutile	4.2
Quartz	21.8	Pyrite	1.5
Orthoclase (molecule)	21.2	Apatite	1.2
Chlorite	11		99.6
Calcite	7.8		
Sericite	4		

All the lime shown in the analysis is required to form calcite with the carbon dioxide, so that the plagioclase, whatever its original composition, must at present contain very little lime and is calculated as albite. The appearance of the thin section indicates that the chemical determination of the pyrite may be a little low and that a portion of the iron, here calculated as titanic iron ore, should really be estimated as pyrite.

On the north side of the National Belle knob a mass of this same porphyry has been altered by metasomatic processes to a very light-gray rock in which the feldspars are transformed to dull kaolin-like aggregates while the quartz phenocrysts are apparently unchanged. A few minute veinlets, filled with kaolin, occur in the hand specimen. The groundmass is gray in color, compact in texture, and abundantly sprinkled with minute crystals of pyrite. This alteration is evidently directly connected with the deposition of the National Belle ore bodies, and is merely one phase of the metamorphism which has given rise to the siliceous mass in which the ore occurs.

Under the microscope rounded and embayed phenocrysts of quartz containing minute fluid inclusions, and pseudomorphous aggregates after feldspar, are seen to lie in a finely crystalline, granular groundmass. The feldspar phenocrysts have been changed to pseudomorphs of kaolin, diaspore, and quartz. The diaspore is intimately associated with the kaolin, in which it often occurs embedded in ragged, shred-like areas. Near it there is sometimes a small amount of a colorless isotropic mineral with a fairly high refractive index, which has thus far defied identification. The groundmass is a finely crystalline mosaic of quartz and kaolin with small scattered crystals of pyrite and occasional crystals of rutile and apatite. Sericite was not noted, but is perhaps not entirely absent.

A chemical analysis of this rock is given under II, on page 127, and although the two rocks are not from the same mass, there can be little doubt that they were both originally of the same character.

It may be that the nearly identical contents in alumina shown by the two analyses is merely a coincidence, but it is probable that it denotes practical constancy of the alumina during the change which has taken place in the rock.

The notable features of the alteration are the introduction of silica, water, and sulphur, the total removal of iron (except that combined with sulphur to form pyrite), magnesia, and carbon dioxide, and the almost entire abstraction of lime and alkalies. The formation of diaspore brings this alteration close to that described at the Polar Star mine, the original rocks in both cases being of similar chemical composition, while the addition of silica and the formation of kaolin, usually without sericite, is characteristic of the Red Mountain mines.

Ignoring the small amount of the unknown isotropic mineral, the mineralogical composition of the altered rock may be roughly calculated from the chemical and microscopical data as follows:

Mineralogical composition of altered monzonitic porphyry from National Belle mine.

Constituent.	Per cent.	Constituent.	Per cent.
Quartz	60.9	Apatite	.6
Kaolinite	26.3	Rutile	.6
Pyrite	5.6		98.4
Diaspore	[a]3.8		
Sericite	.6		

[a] The diaspore of this rock was also isolated with hydrofluoric acid. It appeared to be fully as abundant in the residue as in the similar residue from the Polar Star rock, described on page 121, and the above calculation may be low.

This is a very different alteration from that normally brought about by waters carrying alkaline carbonates, which, as Lindgren[1] has shown, tend to form sericite and carbonates in the wall rock. It is believed to be due to the action of acid waters.

It is unfortunate that the study of the metamorphism connected with the Red Mountain ore bodies is at the present time practically confined to the surface. However, as far as can be judged from the mine dumps, metamorphism of the character described accompanied the ore bodies to the greatest depth explored.

On Anvil Mountain, which forms the southern end of what has been called for convenience the Red Mountain Range, the bleached rocks, when critically examined, are found to present some variations in composition. Thus the country rock of the Brobdignag claim, probably originally andesitic, is converted into a fine-granular aggregate of quartz and barite, with a little sericite. It is impregnated with pyrite and is traversed by some veinlets of sericite or kaolin. At the Zuñi mine the country rock, which was evidently an andesite or latite, has been recrystallized near the ore body to a mass of quartz, sericite, kaolin, and barite, with a little epidote in small grains. Some rutile and some undetermined minerals in minute grains are also present. At the Mystery claim, on the summit of Anvil Mountain, the rock (rhyolite?) has been changed to a nearly white, rather porous mass showing no traces of original igneous structure. Under the microscope it shows faint outlines of former phenocrysts, which become nearly invisible between crossed nicols. The rock consists chiefly of quartz and alunite in a fine-granular aggregate, with a little kaolin and rutile. At John Roland's tunnel, about 1½ miles southeast of the Mystery claim, an opportunity was presented for studying some of the steps of alteration. About 150 feet from its mouth the tunnel cuts through a very irregular vein-like mass of kaolin and continues beyond it for 200 feet or more. Near the breast the rock, although altered, can be recognized as an andesite, or closely related rock. It is greenish gray in color and shows outlines of small feldspar phenocrysts. Under the microscope, although the original porphyritic structure is partly preserved, the rock is seen to be completely altered. The phenocrysts of plagioclase are changed to sericite and quartz, while the augite and perhaps other dark constituents are represented by pseudomorphs of chlorite and calcite. At about 150 feet from the fissure the country rock is already bleached to a light greenish-gray tint and the original texture partly obliterated. Under the microscope it is seen to be a secondary aggregate, consisting chiefly of sericite, quartz, and calcite, retaining, however, outlines of the original porphyritic structure. About 45 feet from the fissure the rock is nearly white and shows very faint traces of original texture. In general appearance it is identical with most of the bleached and metamorphosed rock of the Red Mountain Range. Microscopically examined, the outlines of former phenocrysts are distinctly visible, but the whole rock is recrystallized to a very fine aggregate of quartz and sericite with some leucoxene (rutile). The former feldspar phenocrysts are now nearly pure sericite. Lastly, a specimen taken from the wall of the fissure is a nearly white, compact rock in which close scrutiny fails to detect any vestige of primary structure. Under the microscope the rock appears as a finely crystalline aggregate consisting of quartz and sericite, with a little brownish isotropic material occurring in minute veinlets. Recrystallization in this case has not only been complete, but there has been such thorough rearrangement of the crystallizing material as to obliterate all traces of primary structure. The alteration has plainly been accompanied by removal of iron, lime, magnesia, and probably other constituents. Whether alumina has been removed is an open question, but the fact that the fissure from whence the metamorphosing solutions penetrated the inclosing rock is itself filled with a vein-like deposit of kaolin shows that at some depth both potash and alumina have been removed from the country rock and concentrated as kaolinite within the fissure walls.

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[1] The gold-quartz veins of Nevada City and Grass Valley districts, California: Seventeenth Ann. Rept. U. S. Geol. Survey. Pt. II. 1896, p. 172.

The conspicuous metamorphism of the Red Mountain region has undoubtedly involved rocks of various kinds, reducing them all to light-colored secondary aggregates of similar appearance. Andesites, latites, monzonite-porphyry, and rhyolite have been altered to products which often give little indication of the nature of the original rock. But in many portions of the quadrangle the rhyolitic rocks show certain characteristic phases of metamorphism in connection with ore deposition which seem to merit some special notice. This rock, when acted upon by ore-bearing solutions, is particularly susceptible to recrystallization into secondary aggregates of quartz and sericite, quartz and kaolin, or quartz, sericite, and kaolin. As a general rule such metasomatic alteration is accompanied by more or less replacement of the rock by ore, as may be seen in the Tom Moore or Silver Ledge mines.

No favorable opportunity was presented for studying in detail the metasomatic processes which accompanied the deposition of ore in the monzonitic stocks, such as Sultan Mountain. But so far as observed the alteration is not conspicuous.

PARAGENESIS OF THE LODE AND STOCK ORES.

By *paragenesis* is here meant the association of the various ore and gangue minerals with special reference to the order and mode of their formation.

Beyond the common and well-known derivation of certain secondary minerals in the zone of oxidation, as, for example, anglesite or lead sulphate from galena, the directly observable paragenesis of the ores offers few points which can be embodied in any general statement of regular association. As a general rule the ore minerals which are found together in any one deposit have formed contemporaneously, and cases are rare in which a definite and constant succession of different ore minerals can be recognized. In the Tom Moore lode chalcopyrite appears to have formed later than tetrahedrite. The same relation was observed in the Dives lode, where masses of tetrahedrite are surrounded by an envelope of chalcopyrite from which radiate still younger quartz crystals. But in many other lodes these two minerals occur in such irregular relations as to point to practically contemporaneous crystallization. In the Empire-Victoria lode, on Sultan Mountain, hübnerite and fluorite have been formed since the ore was deposited. Native copper, wherever seen, was plainly of later origin than the sulphide ores with which it was associated. Native silver was seen only in detached specimens of ore, but it occurs characteristically in the upper portions of the deposits and is undoubtedly of secondary origin. Quartz of at least two generations is common, as shown by the relatively barren stringers of this mineral, which can be found traversing the ore in many of the deposits.

Free gold occurs usually embedded in quartz and associated with pyrite or chalcopyrite. In the Sunnyside, Sunnyside Extension, and

Camp Bird mines it is also associated with pale-yellow sphalerite and fluorite. Some specimens were seen from the Sunnyside Extension mine in which the gold occurred as implanted crystals on quartz and was therefore of later age than the latter.

Unfortunately there are at present few opportunities for studying the occurrence of proustite and argentite in the Silverton quadrangle. In the Ridgway mine much of the argentite occurs implanted on, or wedged between, the quartz crystals of small vugs, and was the last mineral to crystallize. It has been the universal experience in the Silverton district that argentite, proustite, and polybasite are not found below a very moderate depth. The data at hand do not permit of a definite statement as to the depth at which these rich argentiferous minerals change to low-grade ore, but the indications are that it is less than 1,000 feet, although it is well known that in other regions some of these minerals extend to greater depths. It is probable, although not at present demonstrable, that in the Silverton region proustite, argentite, and polybasite are of secondary origin and indicate a zone of enrichment of the kind to which Emmons[1] and Weed[2] have recently called attention.

The downward change from galena through richly argentiferous copper ores to chalcopyrite and pyrite, which was found to be a characteristic feature of many of the Red Mountain mines, is a case of paragenesis on a large scale, which will be discussed in the following section on the origin of ores. The origin of the rhodonite, which is so abundant in many of the lodes of the northern half of the quadrangle, and its exact relation to the quartz and ore which accompany it constitute a puzzling problem, for which no satisfactory solution has been found. Such a solution must account for the presence of large lenticular or partition-like masses of rhodonite, carrying a few specks of low-grade ore, and dividing the ore bodies longitudinally into two or more parts, and for the presence of patches and stringers of rhodonite. In the Saratoga mine rhodonite has formed by metasomatic replacement of limestone. It is possible that in such lodes as the Sunnyside the large, solid masses of rhodonite within the vein may represent metasomatically altered horses of country rock. This, however, is merely a hypothesis, which requires confirmation before acceptance. It has undoubtedly been deposited also in open fissures as a true vein mineral.

ORIGIN OF THE LODE AND STOCK ORES.

That the ores of the Silverton quadrangle were deposited from aqueous solution is a proposition which, in the light of present knowledge, needs no special demonstration. They were precipitated partly in open spaces, to which the solutions had access, and partly as replacements of various rocks through metasomatic action. Their deposition was accompanied by chemical and mineralogical changes in the immediately adjacent country rock, producing effects which in the majority of cases diminish rapidly in intensity with increasing distance from the fissure walls. As far as is known, the deposition of ore within the fissures was not affected by differences in character of the wall rock. It is believed that the facts presented in the descriptive portions of this report all indicate an initial primary deposition by ascending mineralized waters. It is probable, as pointed out by Lindgren[1] and Van Hise,[2] that these waters were originally meteoric waters, which gained their heat and collected their mineral contents during slow downward and lateral percolation through the rocks, and were subsequently gathered as ascending currents into the main fissures. It is not known from what particular rocks they extracted their metalliferous burden, nor at what depth most of the solution took place.

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[1] The secondary enrichment of ore deposits: Trans. Am. Inst. Min. Eng., Vol. XXX, 1900, pp. 177-217.

[2] Enrichment of mineral veins by later metallic sulphides: Bull. Geol. Soc. Am., Vol. XI, 1900, pp. 179-206.

That the entire process of ore deposition was directly connected with volcanism can scarcely be doubted. The most obvious aspects of this connection are threefold: (1) The mechanical formation of the fissures; (2) the accession of heat, whereby the chemical activity of underground water was intensified; and (3) the accumulation of vast masses of igneous rock from which, at some depth, the constituents of the ore minerals were probably derived. It is possible that there should be included here also the evolution of carbon dioxide, sulphydric acid, and probably other volatile substances, as active solvent and chemical agents.

Very different views are held by various investigators in regard to the extent to which pneumatolytic processes, due to the emanation of highly heated gases and vapors from solidifying igneous rocks, are responsible for ore deposition. Van Hise, in his suggestive paper just cited, practically ignores pneumatolysis as a factor in the formation of ore bodies. Kemp,[3] on the other hand, considers that meteoric waters have little or no efficiency in the original concentration and deposition of ores, and that the waters of ore-bearing solutions, together with their dissolved mineral constituents, are of intratelluric origin, and are given off at high temperatures by masses of igneous rock in process of congelation. Various intermediate views are held by many European geologists and writers on ore deposits, notably by Beck, Vogt, and Du Launay. The evident connection between ore deposition and volcanism, or at least the products of volcanism, the presence of fluorite and hübnerite in some of the lodes of the Silverton region, and the occurrence of alunite and diaspore, in connection with metasomatic alteration of the country rock apparently brought about by acid waters and locally very pronounced in character, are all to some extent indicative of pneumatolytic processes. But, as Lindgren[1] remarks, fluorine and boron compounds are found in some deposits which are certainly not of pneumatolytic origin, nor even formed at high temperature. The Silverton lodes, as a whole, possess neither the distribution nor the mineralogical characters of those deposits to which in the light of present knowledge an essentially pneumatolytic origin can be most safely assigned. The known igneous masses had certainly solidified and probably had lost much of their heat before the lode fissures were formed. It is most probable that the transportation and concentration of the Silverton ores was effected chiefly by meteoric waters, which derived their chemical and mechanical energy mainly from the heat connected with volcanism and from pressure, but possibly in some minor part, also, to gases and vapors given off at high temperature by solidifying igneous rocks and taken into the deeper meteoric circulation.

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[1] The gold-quartz veins of Nevada City and Grass Valley districts, California: Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. II, 1896, p. 176.

[2] Some principles controlling the deposition of ores: Trans. Am. Inst. Min. Eng., Vol. XXX, 1900, p. 47.

[3] The rôle of the igneous rocks in the formation of veins: Trans. Am. Inst. Mining Eng., Richmond meeting, 1901.

It is difficult to determine the exact character of the solutions which deposited the ore of the Silverton quadrangle. Many natural solvents are known for the common gangue minerals, for sulphide minerals, and for gold. According to Doelter's[2] experiments, pyrite, sphalerite, galena, stibnite, chalcopyrite, arsenopyrite, and bournonite are all appreciably soluble in pure water under the influence of moderate heat (80° C.) and pressure. Galena and pyrite are soluble in water containing carbon dioxide, and gold and copper are soluble in solutions of sodium carbonate.[3]

Solutions of sulphydric acid or sodium sulphide are relatively active solvents of gold, as well as of pyrite, chalcopyrite, bournonite, arsenopyrite, galena, and sphalerite, according to the investigations of Becker[4] and Doelter.[5] The experiments of Doelter in particular indicate that heat and probably pressure increase the solvent action, although the law of this increase of the different minerals is unknown. Solution is also favored by a great preponderance in the mass of the solvent and by the long contact of solvent and solid under favorable conditions of heat and pressure. Obviously these latter conditions are those common in nature, but which can be only very imperfectly realized in the laboratory. It appears, therefore, that nearly all aqueous solutions that occur in nature may, under suitable conditions of heat and pressure, act as solvents and carriers of the heavy metals and their sulphides. Some solutions are undoubtedly more efficient than others under like conditions, but where so many unknown elements, such as degree of heat, amount of pressure, relative mass of solvent and solute, and duration of the process, enter into the problem, it is rarely possible to arrive at even approximate quantitative results.

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[1] Metasomatic processes in fissure veins: Trans. Am. Inst. Min. Eng., Vol. XXX, 1900, p. 644.

[2] Chemische Mineralogie, Leipzig, 1890, p. 188.

[3] Doelter, loc. cit., pp. 190-191.

[4] Natural solutions of cinnabar, gold, and associated sulphides: Am. Jour. Sci., Vol. XXX, 1887, p. *199-210*. Also Mon. U. S. Geol. Survey, Vol. XIII, 1888, pp. 432-433.

[5] *Loc.* cit., p. 192.

As the lode and stock ores were deposited from solutions, it follows that the chemical action of these solutions on the wall rocks offers a very important mode of attacking the problem of their chemical character. The nature of this metasomatic alteration has been discussed at some length on pages 114–131 of this report. It is concluded that the solutions producing it were chemically different in different portions of the quadrangle. The very slight development of carbonates in connection with some lodes, and their entire absence in others, indicate that carbon dioxide or alkaline carbonates were not abundant in the mineralizing waters, although probably not wholly absent in the case of deposits such as those of Silver Lake Basin. The silicification observed in connection with the Red Mountain deposits, with the removal of most of the bases, including in some cases part of the alumina and the addition of sulphur and water, indicate the action of acid waters, probably containing free sulphuric acid. But here another element, which can not be ignored, enters the problem. Water containing sulphuric acid and ferric sulphate is known in the Red Mountain region to-day—not as ascending thermal water, but as (in part at least) descending water, which owes its acidity to the oxidation of previously deposited iron pyrite. The capacity of this water to effect some changes in the country rock is beyond doubt. It is not unlikely, therefore, that much of the alteration visible in the Red Mountain region is the result of complex processes involving the action of solutions of different characters and origin and acting upon any given mass of the rock at different times.

Writers on the genesis of ore deposits very commonly speak of the "circulation," "currents," or "flow" of the ore-bearing solutions within the fissures. Although the use of these terms is convenient and can not be regarded as entirely incorrect, yet it is believed that it has tended to give artificial or false conceptions in regard to the actual processes of ore deposition in many veins, particularly in large veins. Ore deposited by solutions having obvious movement through a fissure should exhibit the phenomenon called by Posepny crustification—i. e., it should be deposited in successive layers or coatings upon the walls of the fissure.[1] But this structure, formerly so much insisted upon as evidence of deposition in open fissures, is, as a matter of fact, of comparatively rare occurrence even in veins which on other evidence are demonstrably simple fissure fillings. In most of the important lodes of the Silverton quadrangle no crustification can be detected. The fissures are filled by coarsely crystalline allotriomorphic aggregates of ore and gangue (massive structure), and there is no evidence to show that such a structure could result from successive deposition upon the walls of the fissure until the whole was finally filled. On the contrary, crystallization has proceeded simultaneously from many points within the solution. Quartz, galena, pyrite, sphalerite, chalcopyrite, and other minerals have formed practically contemporaneously about local centers of crystallization scattered irregularly through the solidifying mass. It is difficult to conceive all the details of a process which results in the formation from aqueous solution of an irregular allotriomorphic aggregate of minerals differing so widely in specific gravity. But reasoning from analogy with similar structures met with in petrology and in the arts, it is fair to assume that this structure in veins is the result of the undisturbed crystallization of a nearly motionless saturated solution. In other words, it was the crystallization of a reservoir so large, in comparison with the current or currents which circulated through it, as to have been itself free from megascopic motion. The conditions which induced crystallization were present throughout the mass of material which filled the fissure, and solidification, instead of proceeding gradually from the walls inward, took place almost simultaneously, although not necessarily with rapidity, throughout the mass. Obviously this massive structure and crustification may be present in the same vein. In such cases deposition appears to have begun by crustification next the walls, passing at a later stage into the more general mode of crystallization indicated by what has been described as massive structure.

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[1] It is perhaps hardly needful to point out that the converse of this proposition is not necessarily true.

Attention has been strongly drawn of late, through the writings of De Launay,[1] Van Hise,[2] Weed,[3] and Emmons,[4] to the important part played by secondary sulphide enrichment in the formation of many ore bodies, particularly those carrying copper and silver. As a probable example of such an enriched deposit, Mr. Emmons[5] has cited the Yankee Girl ore body. Unfortunately, at the time Mr. Emmons visited the mine, in 1888, but little attention had been given to the subject of secondary sulphide enrichment, while at the present day the state of the workings is such as to render impossible the verification by direct observation of this application of the theory. However, there are many facts which point strongly toward secondary enrichment as the true mode in which the rich ore bodies, not only of the Yankee Girl, but of the Guston, Silver Bell, and other mines, were formed. To have the important facts fresh in mind, it will be well to review briefly the characteristic features of these ore bodies which bear upon this question.

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[1] Contribution à l'étude des gîtes métallifères: Ann. des Mines, Vol. XII, 1897, pp. 119-228.

[2] Some principles controlling deposition of ores: Trans. Am. Inst. Min. Eng., Vol. XXX, 1900, pp. 27-177.

[3] Enrichment of mineral veins by later metallic sulphides: Bull. Geol. Soc. Am., Vol. XI, 1900, [illegible]-206.

[4] [illegible] secondary enrichment of ore deposits: Trans. Am. Inst. Min. Eng., Vol. XXX, 1900, pp.

[illegible] it., p. 19.

The ore first struck, in some cases actually at the surface, consisted chiefly of argentiferous galena. At a depth which varied somewhat in different mines, but which appears to have been usually less than 200 feet, this galena changed to an ore consisting chiefly of highly argentiferous stromeyerite. At a still greater depth—usually about 500 feet—the stromeyerite changed to argentiferous bornite, still deeper to chalcopyrite and pyrite, and finally to low-grade auriferous and argentiferous pyrite. These changes were more or less irregular and overlapping. Thus pyrite was found at nearly all levels, and bunches of galena were met with far below the levels at which it ceased to be the dominant ore. Small rich streaks of bornite were also found, with chalcopyrite and pyrite, below the levels where it occurred in large masses. According to Schwarz,[1] who opened and worked many of the ore bodies of the Red Mountain district, the rich portions of the ore bodies were always associated with open water-bearing fissures, and he apparently regarded the entire deposits as formed primarily by deposition from the water entering through these fractures. It seems to be a well attested fact that at a depth of about 500 feet there was encountered in the Yankee Girl and Guston mines a fault or "slip plane" with low westerly dip, and, further, that the richest ore occurred just above this seam, which was filled with clay-like gouge. Moreover, most of the water entering the mines came in at or above this fault. The acid character of this water was well known, and it carried in solution large amounts of the sulphates of iron and copper. Lastly, the mines are situated within a valley of erosion, within which the ore bodies outcrop at different levels. It is not known what thickness of material has been removed in the shaping of the present topography, but it probably exceeds 2,000 feet. It is hardly conceivable that the observed relation between the vertical variations in the ore bodies and the present topographic surface is a haphazard one. It is without much doubt genetic.

Ore deposits which show a fairly orderly vertical succession from rich sulphides near the ground-water level down to poor sulphides at greater depth are in nearly all cases regarded as the product of two concentrations—a concentration by ascending waters and a further concentration by descending waters.[2] By the former are deposited lean ores, found in the deepest workings, which are enriched to a greater or less depth by the downward-moving solutions. As Van Hise has pointed out, these two processes may go on at the same time, or they may have operated successively on any given vertical section of the ore body. The facts obtainable in the Red Mountain region point to the original deposition of bodies consisting chiefly of pyrite carrying a little gold, silver, and copper. The lead may have originally been sparingly deposited as galena with the pyrite. It is into such low-grade auriferous and argentiferous pyrite, carrying 2 or 3 per cent of copper and containing an occasional bunch of galena, that the rich ore bodies passed in the Guston, National Belle, Silver Bell, Hudson, and Yankee Girl mines when the ore became too poor to work.

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[1] Trans. Am. Inst. Min. Eng., Vol. XVIII, 1890, p. 144.

[2] Van Hise, op. cit., p. 101.

Subsequently, as the surface of the region was reduced by erosion, descending waters, which found ready passage through the fissured and mineralized rocks of the region and through the upper portions of the lean primary ore bodies, effected a second concentration, which produced the rich ore formerly mined. The penetration of this water into the primary pyritic ore must have been aided by the porous, crumbling character of much of the latter. These waters are known to have been heavily laden with the sulphates of iron and copper and other salts, resulting from oxidation of the upper portions of the ore bodies. As these solutions penetrated downward they probably acted upon the low-grade pyritic ore, replacing part of the iron sulphide by sulphides of copper and silver. Apparently much experimental work remains to be done before all the details of the chemical processes involved will be actually known, but the probability of the transformations outlined is shown by the following chemical equations taken from Van Hise's suggestive paper.[1]

By taking solutions containing merely the sulphates of copper the production of chalcopyrite from iron sulphides may be written as follows:

Cupric sulphate + ferrous sulphide = chalcopyrite + ferrous sulphate.

$$CuSO_4 + 2\,FeS = CuFeS_2 + FeSO_4$$

Or,

Cupric sulphate + pyrite + oxygen = chalcopyrite + ferrous sulphate + sulphurous anhydride.

$$CuSO_4 + 2\,FeS_2 + O_4 = CuFeS_2 + FeSO_4 + 2\,SO_2$$

Bornite may be produced as follows:

Cuprous sulphate + cupric sulphate + ferrous sulphide = bornite + ferrous sulphate.

$$Cu_2SO_4 + CuSO_4 + 3\,FeS = Cu_3FeS_3 + 2\,FeSO_4$$

Or,

Cuprous sulphate + cupric sulphate + pyrite + oxygen = bornite + ferrous sulphate + sulphurous anhydride.

$$Cu_2SO_4 + CuSO_4 + 3\,FeS_2 + 6\,O = Cu_3FeS_3 + 2\,FeSO_4 + 3\,SO_2$$

But bornite may also be formed by direct action of the copper sulphates on chalcopyrite, as follows:

Chalcopyrite + cupric sulphate + oxygen = bornite + ferrous sulphate + sulphurous anhydride.

$$2\,CuFeS_2 + CuSO_4 + O_2 = Cu_3FeS_3 + FeSO_4 + SO_2$$

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[1] Some principles controlling the deposition of ores: Trans. Am. Inst. Min. Eng., Vol. XXX, 1900, pp. 111-112.

Chalcocite may be produced from pyrite, chalcopyrite, or bornite, as follows:

Cuprous sulphate + pyrite + oxygen = chalcocite + cuprous sulphate + sulphurous anhydride.

$$Cu_2SO_4 + FeS_2 + O_2 = Cu_2S + FeSO_4 + SO_2$$

Cupric sulphate + chalcopyrite + oxygen = chalcocite + cuprous sulphate + sulphurous anhydride.

$$CuSo_4 + CuFeS_2 + O_2 = Cu_2S + FeSO_4 + SO_2$$

Cupric sulphate + bornite + oxygen = chalcocite + ferrous sulphate + sulphurous anhydride.

$$CuSO_4 + Cu_3FeS_3 + O_2 = 2Cu_2S + FeSO_4 + SO_2$$

> Of course it is understood that these sulphides overlap one another. Before the iron sulphide has wholly been replaced by chalcopyrite bornite may appear. At the place where bornite has become reasonably abundant chalcocite may be found. However, certain general statements may be made. If the dominating material is iron sulphide, the copper mineral which is present is likely to be chalcopyrite rather than the richer sulphurets. Chalcopyrite, on the one hand, is likely to be associated with the pyrites, and on the other hand with bornite, or even chalcocite. Bornite and chalcocite are likely to be associated with each other and with chalcopyrite, but with the first two compounds iron sulphide is likely to be subordinate or absent.[1]

When the sequence of formation, deduced largely on theoretical grounds by Van Hise, is compared with the facts of occurrence in the Yankee Girl and Guston mines, the close correspondence affords striking confirmation, not only of the probable truth of the theory of secondary sulphide enrichment, but also of its applicability to these deposits. As far as the cupriferous sulphides and pyrite are concerned, the relations are exactly those which might be expected as a result of the downward percolation of solutions of copper sulphates through a body of low-grade pyritic ores.

The iron sulphates, of course, can not act directly, as do the copper sulphates, in enriching the ore. Their rôle is limited to an attack upon the previously formed sulphides, which converts them into sulphates and redeposits them in part as sulphides below the zone of oxidation.[2] They thus aid, although in a different manner, the copper sulphates in effecting a secondary concentration of the ores. It is probable that, owing to the slight solubility of its sulphate, the lead is deposited as sulphide at an early stage in the downward movement of the solutions, and that, through a constant and prolonged continuance of this process, as the outcrop of the ore body is lowered by erosion, there have resulted the masses of nearly pure galena ore which occurred above the chalcocite or stromeyerite.

The application of the theory of secondary sulphide enrichment to any ore body naturally presupposes the existence of small amounts of the valuable metals in the low-grade ore of primary deposition. But this fact is not always easily determined, as mining operations are not often pushed very far beyond the depth at which the ore ceases to pay, and it is not always possible to determine the actual downward limit of the enrichment. But the numerous assays made of the unworkable pyrite in the deepest levels of the Guston, Silver Bell, and National Belle mines all show the presence of a fraction of an ounce of gold and a few ounces of silver. Lead has not been determined. It is probable that in the assays made for practical purposes no attempt was made to determine its presence in small amounts. It should further be borne in mind that the enrichment in question is not of necessity due solely to waters which have descended from the upper portion of the selfsame ore deposit. The descriptions of the mines indicate that some of the second concentration was effected by waters which may have traveled laterally, from some distance, through rocks which are themselves mineralized and may contain considerable bodies of ore as yet undiscovered.

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[1] Van Hise, op. cit., p. 112.

[2] The secondary enrichment of ore deposits, by S. F. Emmons: Trans. Am. Inst. Min. Eng., Vol. XXX, 1900, p. 210.

The theory of secondary enrichment, which is regarded as giving the most probable and satisfactory explanation of some of the peculiar features of the Red Mountain deposits, has, if its application is correct, certain very important and practical consequences. It indicates that the rich ores formerly mined have a working lower limit which is probably less than 1,000 feet in depth. While small bodies of rich ore may occur deeper than this, it is probably not worth while prospecting for them when once the depth has been reached at which the ore is practically all low-grade pyrite. On the other hand, as some pyrite occurs at all depths, and as the vertical limits of the zones of enrichment are necessarily irregular and overlapping, it is unwise to suspend operations too quickly, merely because the ore falls off locally in value and becomes pyritic.

Passing from the Red Mountain stock deposits to the lodes occurring in other portions of the quadrangle, the evidence of secondary enrichment is less easily read. It seems very probable that the rich silver minerals, such as polybasite, proustite, and argentite, are the result of secondary enrichment similar to that described by Weed[1] in the Neihart district in Montana. In the San Juan region, however, the actual steps of the alteration of lower-grade ores into those rich in silver can not be traced. The evidence for a secondary origin consists in the fact that these rich minerals occur largely in vugs, and that in several cases they pass at moderate depths into low-grade ores. These features, however, do not in themselves preclude the idea that the minerals are primary, and resulted from original deposition in a zone where ascending and descending waters mingled.

In the Tomboy mine the undoubted association of the richest gold ore with shattering and movement in the lode, accompanied by some oxidation far below the level of general weathering, is suggestive of secondary enrichment, but it is hardly safe to assume that this process has actually been effective. Both in this mine and in the Silver Lake mine it is stated by those in charge that rich bunches of ore are commonly associated with secondary or "post-mineral" fissuring, which, if true, is significant of some secondary enrichment below the zone of oxidation.

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[1] *Geology* of the Little Belt Mountains, Montana: Twentieth Ann. Rept. U. S. Geol. Survey, *Pt. III, 1900*, pp. 421-422.

THE GROUND WATER.

In many mining regions the level at which the ground water stands, or, more accurately, the shape of its surface and the relation of the latter to the topography, is a matter of much importance, as by it are frequently determined questions of mine drainage and the depths at which oxidized ore changes to unoxidized ore. In the Silverton region, however, erosion has proceeded with such celerity relative to processes of oxidation and weathering that the change in question is largely independent of the depth of the ground water, and the latter is accordingly of less moment to the miner.

In most regions of considerable relief the upper surface of the ground water corresponds to a very subdued copy of the topographic relief. In the exceedingly rugged and much fissured Silverton area, however, the ground-water surface is very much less accentuated than the topography. Not only is the water tapped and drained away by the deeply cut ravines, but its level is often modified by the tunnels run into the mountains, sometimes several thousand feet below the crests of the ridges. Under these conditions it is often practically impossible to predict at what depth the ground-water surface will be encountered in mining operations.

Tunnels driven in from the floors of the high basin do not, as a rule, encounter permanent ground water. Those run below the basins, such as the Unity tunnel, or from the bottoms of the deeper ravines, such as the Highland Mary tunnel in Cunningham Gulch, the Bonanza tunnel near Animas Forks, the Old Lout tunnel in Poughkeepsie Gulch, the Revenue tunnel, the North Star tunnel on Sultan Mountain, and the Empire tunnel near Silverton, usually tap the ground water and artificially lower its surface within the overlying rock masses. In the shafts of the Red Mountain district permanent water is encountered at depths varying from 50 to 200 feet below the surface, dependent upon the location of the shaft and the seasonal fluctuations of the ground-water surface, which sometimes exceed 50 feet. In the Red Mountain district the ground-water surface is nearest the topographic surface in spring or early summer.

REPLACEMENT DEPOSITS.

Between certain replacement deposits and the metasomatic impregnations frequently accompanying fissure veins or ore stocks no sharp distinction can be made. Whether the deposit shall be classed as a vein or as a replacement deposit may depend simply upon the quantitative relation between the ore found within the walls of the fissure and that occurring in disseminated particles or in larger masses in the metasomatic country rock. The Red Mountain stocks undoubtedly owe their form partly to metasomatic replacement, and might almost as well be described under this head. Ore-bearing fissures traversing rhyolite rocks are in this region frequently accompanied by notable replacement of the wall rock by ore. But there are a few deposits where replacement is so conspicuous a feature and where so small a part of the ore occurs within distinct fissure walls that but little doubt need arise as to their proper classification. They are, however, neither abundant nor relatively important in the Silverton quadrangle.

Direct replacement of limestone by ore occurs on the eastern side of Ironton Park, where, for some distance, a thick bed of white crystalline limestone, probably of Devonian age, is exposed beneath Tertiary volcanic rocks. At the Saratoga mine the ore, consisting in its unoxidized state of pyrite, chalcopyrite, and galena, with perhaps a little argentite, has replaced the upper portions of this limestone to a varying depth. The ore-bearing solutions have been chiefly active along the contact between the limestone and an overlying andesitic breccia or tuff belonging to the Silverton series. A little Telluride conglomerate, consisting largely of limestone pebbles, occurs near the adit of the mine, between the limestone and the overlying volcanic series. It has been silicified and probably partly replaced by ore, but was not recognized as present in the main workings. The ore is sometimes associated with rhodonite, which has also replaced the limestone and frequently incloses residual kernels of the latter. The ore was probably deposited by solutions rising through one or more northeast-southwest fissures, although no direct connection of the ore with any of the fissures could be made out. In the Baltic mine a similar but lower-grade ore occurs, also as a replacement of the upper portion of the same bed of limestone. This ore, however, is directly connected with an ore body filling a fault fissure (the Mono vein). In the Maud S. claim, which is part of the Baltic group, some argentiferous copper ore occurred in bunches in the same limestone alongside of a fault fissure. The direct connection between the replacement ore bodies of the Baltic group and a system of northeast-southwest fault fissures strongly suggests that a similar connection does or did formerly exist in the case of the Saratoga ore body.

In the southern portion of the quadrangle the Devonian limestone at the east base of Sultan Mountain carries disseminated particles of native silver on the Fairview claim, while in an unknown prospect near the King mine a body of chalcopyrite occurs partly in a fissure and partly as a replacement of the limestone near the fissure. The ore in this case makes largely at the underside of the limestone, where it rests upon quartzite.

The facility with which the rhyolitic rocks of this region become to a greater or less extent metasomatically replaced by ore has already been noted. In most cases such replacement is a minor accompaniment of the deposition of ore in fissures. But at the Silver Ledge mine replacement is the dominant mode of occurrence. The ore, consisting of galena and sphalerite, occurs metasomatically, replacing rhyolite in the vicinity of a zone of fracturing and faulting trending about N. 20° E. These fractures contain crushed country rock and ore, and there has evidently been movement along them since the ore was deposited. The principal ore bodies, however, are not found within the fissures, but as irregular replacements of the rhyolite which forms their walls. In some instances bodies of ore have been followed into the country rock for 30 or 40 feet from the main fissures. The replacement is sometimes complete, resulting in solid masses of ore. More often it takes the form commonly described as impregnation; i. e., the ore is more or less thickly scattered through the rhyolite in specks and small bunches. In this case there is no definite boundary to the ore body, and only so much of it is removed as can be profitably worked.

The deposition of the ore has been accompanied by metasomatic change and a complete recrystallization of the rhyolite. The resulting material, which forms the gangue of the ore, is a nearly white, minutely crystalline aggregate of sericite, kaolin, and quartz, with generally a little rutile and occasionally a small amount of calcite. The proportions of the three principal constituents vary, some facies of the rock consisting chiefly of sericite and kaolin, while others are largely sericite and quartz.

MISCELLANEOUS MINERAL RESOURCES.

Compared with the extraction of gold, silver, copper, and lead, all other mineral productions of the quadrangle are insignificant. At present no deposit is being worked for zinc, but sphalerite ores are abundant. As a rule, ore bodies showing much sphalerite with little galena have been little prospected, on account of the smelter penalty attaching to an excess of zinc in ores smelted for other metals. But with the increasing demand for zinc ores it is not unlikely that some of the sphalerite lodes may ultimately be worked for this metal. This, however, may be some years hence, owing to the natural disadvantages under which mining is carried on in so elevated a region.

The occurrence of hübnerite on Cement Creek has aroused expectations of the profitable exploitation of the deposits. The mineral is easily concentrated from its gangue, but it is very doubtful whether it occurs in deposits of sufficient size or constancy to justify extensive operations.

Bog iron ore occurs in the swampy ground along Mineral Creek and in Ironton Park as a deposit from iron-bearing springs. It was formerly used to some extent in Silverton as a flux for smelting, but has at present no market.

Limestone suitable for making lime occurs at several points in the peripheral portions of the quadrangle, and has been burned for lime just below Silverton to supply local demand.

Building stone is not in much request. Good stone might undoubtedly be quarried from the monzonite of Sultan Mountain were there any demand for a building material involving so much labor in its production.

PART II. DETAILED DESCRIPTIONS OF SPECIAL AREAS AND INDIVIDUAL MINES.

INTRODUCTION.

The following descriptions are arranged in general conformity to a geographical plan. The mines in the Silver Lake Basin, in the southeastern part of the quadrangle, are first described. Proceeding northward, other groups are taken up, in the eastern and northeastern portions of the area. Then follow, successively, accounts of mines in the northern, northwestern, western, and southern districts, and, finally, descriptions of the Cement Creek ore deposits in the southwest-central part of the quadrangle.

LODES OF SILVER LAKE BASIN.

General features.—The basin in which Silver Lake lies is a typical high cirque of a kind common in the San Juan Mountains. Its rocky, hummocky floor, with an altitude between 12,000 and 12,500 feet, is inclosed on three sides by cliffs and precipitous slopes culminating in Kendall and Little Giant peaks, which attain altitudes of over 13,400 feet. The basin opens to the north-northwest, and its sloping floor is terminated, at an altitude of about 12,000 feet, by precipices which plunge down to the talus-covered bottom of Arrastra Gulch. Silver Lake,[1] a characteristic mountain tarn, occupies a depression of considerable depth, excavated by glacial erosion in the softer rock behind the sheet of massive andesite at the northern end of the lake, over which the present drainage escapes to Arrastra Gulch. The marks of glacial scoring are still plainly visible on this resistant sill, through which the clear water escaping from the post-Glacial lake has been unable to cut. The original beauty of this little sheet of water has been marred by mining operations, particularly by a partial filling with tailings from the Silver Lake mill. The basin is well above timber line, and the mine buildings are sometimes seriously damaged by snow slides. Mine timbers are packed in from Deer Park by burros, over the col or saddle at the southern end of the basin. The main communication with the mines, however, is by the trail and the wire-rope tramways running up Arrastra Gulch.

The rocks in which the basin has been carved, and which form the country rock of the mines to the depth now worked, belong to the Silverton series and illustrate its typical development. They are prevailingly breccias, in which the angular fragments and the interstitial matrix are composed of the same materials, with practically no admixture of foreign particles. The induration of these breccias has produced rocks which can with difficulty be distinguished from massive lavas. A careful inspection of weathered surfaces, or a microscopical examination, will, however, usually reveal their true clastic nature. The general character of these breccias is andesitic. But they differ from normal andesite, such as occurs in the San Juan formation, by the presence of occasional porphyritic crystals or phenocrysts of orthoclase and quartz, and in the occurrence of orthoclase in the groundmass. The abundance of the phenocrysts of orthoclase feldspar and quartz varies in different varieties or facies of the breccia. As a whole these rocks appear to be most closely related to the latitic group of intermediate rocks. Associated with the breccia are massive rocks of the same general type as the breccias, which have been intruded as sheets and dikes, and possibly in part as contemporaneous lava flows. As examples of these may be cited the masses forming the summit of Round Mountain and the hard sill that holds up the waters of the lake at its northern end. The latter, a dark-gray rock of splintery fracture, shows abundant fresh-looking phenocrysts up to about a centimeter in length, and smaller crystals of hornblende, lying in a compact groundmass. A thin section shows, under the microscope, phenocrysts of labradorite feldspar, brown hornblende, and pale-greenish augite, in a feldspathic groundmass. The augite is partly decomposed to calcite and chlorite, and certain areas of chlorite appear to represent former phenocrysts of biotite. The groundmass, while somewhat obscured by calcite, chlorite, and other products of alteration, appears to consist chiefly of plagioclase, orthoclase, and glass. The accessory minerals are magnetite and apatite. The rock from the summit of Round Mountain is very similar, but the presence of orthoclase in the groundmass is more clearly shown and the augite is fresher and more abundant.

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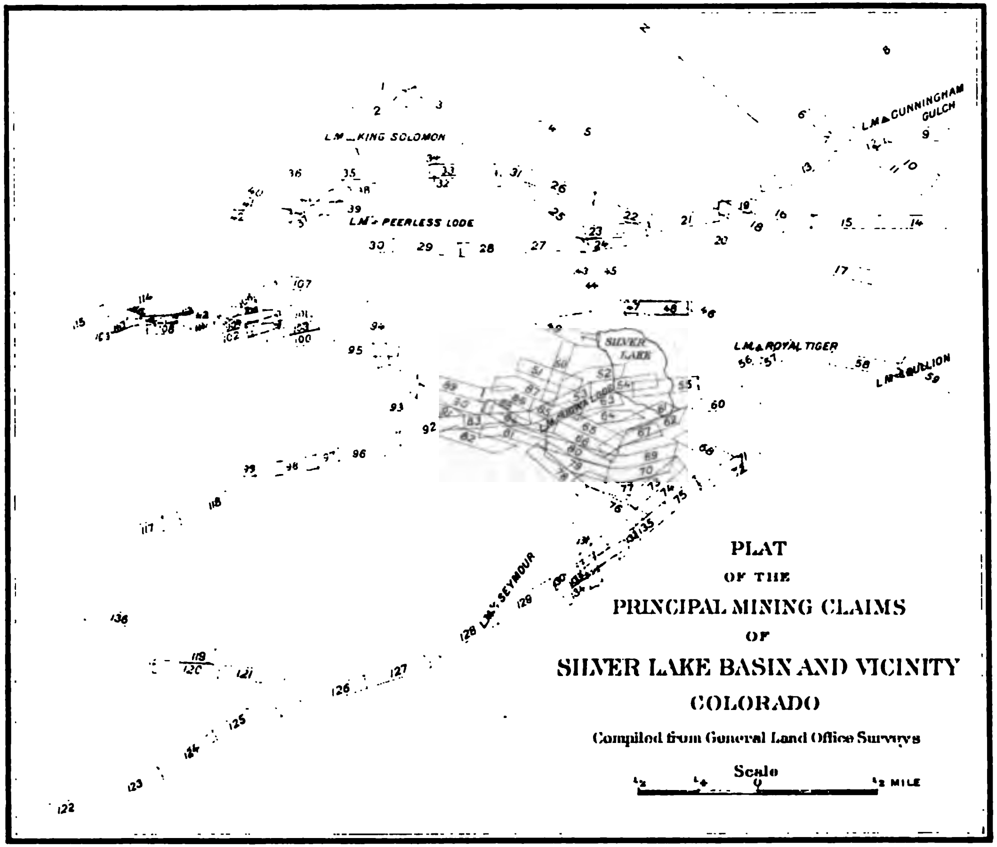
[1] Formerly known as Arrastra Lake, and still so designated on the maps of the General Land Office. This is also the name of the post-office at the Silver Lake mine.

The lodes of Silver Lake Basin are large and prominent, and on this account were discovered and located at an early stage of the mining development of the region. But it was not until the erection of the Silver Lake mill, about 1890, that they were worked on the scale necessary for the profitable and permanent extraction of low-grade ore. They are nearly all fissure veins of comparatively simple form, and have clearly defined walls. The wall rock has been chemically altered by the solutions traversing the fissures and, to a slight degree, impregnated with ore minerals, but it is not regarded as ore and is always readily distinguished from the vein filling.

The lodes wholly or partly within the basin may be divided into two groups. The first group comprises at least two very strong and per-



PLAT
OF THE
PRINCIPAL MINING CLAIMS
OF
SILVER LAKE BASIN AND VICINITY
COLORADO
Compiled from General Land Office Surveys

Scale
½ ¼ 0 ½ MILE

NAMES OF MINING CLAIMS

1 MOUNTAIN QUEEN
2 KING SOLOMON
3 JURA
4 NIGHT BIRD
5 WILHELM
6 HIGHLAND CHIEF
7 LONG TOM
8 BLACK CROOK
9 WM. H. NICHOLS
10 NUMBER 1
11 NUMBER 2
12 HIGHLAND MARY
13 ROBERT BRUCE
14 LOOKOUT
15 MOUNTAINEER
16 SHENANDOAH
17 BIG PINE
18 QUEEN
19 SHENANDOAH NO. 2
20 - - - - - -
21 DIVES
22 CREMORNE
23 YELLOW JACKET
24 NORTH STAR
25 NORTH STAR EXTENSION
26 POTOMAC
27 TERRIBLE
28 SLIDE
29 MAYFLOWER
30 ARGENTINE
31 GENERAL GARFIELD
32 MOUNTAIN QUAIL
33 BIG GIANT
34 BLACK PRINCE
35 ESMERELDA
36 SILVER CROWN
37 JESS
38 EMMA S
39 PEERLESS
40 GOLDEN FLEECE
41 LITTLE GIANT
42 IRON MASK
43 LITTLE SHAVER
44 CROSS CUT
45 GOOD FORTUNE
46 ECLIPSE
47 LAKE VIEW
48 SINA LOA
49 MARTHA
50 ARABIAN BOY
51 SILVER LAKE SPUR
52 MAXWELL
53 SILVER LAKE
54 GRETCHEN
55 ROYAL TIGER NO. 1
56 ROYAL TIGER
57 HOMESTAKE
58 ANNIE
59 BULLION
60 DIAMOND L
61 DUMP
62 GRIP
63 BLACK DIAMOND
64 J. W. COLLINS
65 IOWA
66 STAG
67 CABO
68 DANON
69 AMERICAN BOY
70 PROFESSOR WEDDING
71 BUCKEYE NO. 2
72 BUCKEYE
73 PROFESSOR ZEUNER
74 PROFESSOR WEISBACH
75 LAST CHANCE
76 CAIRO
77 JAFFA
78 ALGIERS
79 SMYRNA
80 WHALE
81 ROCHESTER
82 LENA ALLEN
83 ROUND MOUNTAIN
84 NEW YORK CITY
85 ROYAL
86 RIVINGTON ST.
87 ESSEX ST.
88 PROFESSOR STELZNER
89 GALENA
90 LAST CHANCE
91 BADGER
92 LOWVILLE
93 UNITY
94 PROFESSOR WINKLER
95 EL PASO
96 NEVADA
97 NEVADA EXTENSION
98 HILL
99 HAPPY JACK
100 PEACOCK
101 LITTLE BELLE
102 LUCY
103 ORIENTAL
104 TOM PAINE
105 TOLEDO
106 GREY EAGLE
107 EZRA R
108 MAMMOTH
109 PATHFINDER
110 PROSPECTOR
111 ASPEN
112 SUSQUEHANNA
113 MAC GREGOR
114 LEGAL TENDER
115 SILVER STAR
116 CHLORIDE
117 FREE COINAGE
118 LAST CHANCE
119 CONTRA COSTA
120 DOLLY VARDEN NO. 2
121 ETHAN ALLEN
122 IDAHO NO 1
123 IDAHO NO 2
124 BOWERY
125 SAL CUSTER
126 POMPEII
127 PYRAMID
128 EMMA
129 SEYMOUR
130 CAROLINA
131 LEUCOCITE
132 BERA
133 TITUSVILLE
134 SOLSTICE
135 PANUCO
136 J. B. SMITH

sistent lodes, which may be referred to as the Silver Lake and Titusville lodes. The general course of the fissures of this group is nearly northwest and southeast. The second group embraces a number of shorter lodes, having a general average course about N. 25° W., and lying between the two chief lodes of the first group. The members of the second group are locally spoken of as "north-and-south veins"—an obviously inaccurate expression.

The general dip of all the productive lodes in the basin is northeasterly, although some of them are nearly vertical and often dip locally to the southwest. Those of the first group frequently have a much flatter dip than those of the second group, and the ore is generally of lower grade and more irregular in its occurrence. Large bunches of ore are separated by relatively barren portions of the lode. As a rule the product is a lead-silver ore, consisting chiefly of galena accompanied by sphalerite, chalcopyrite, pyrite, and sometimes tetrahedrite. In some cases the silver may be so low as to be subordinate in importance to the lead. The lodes of the second group have a much steeper dip, the average being probably near 80°. Their ore bodies are usually more regular and of higher grade. Galena is still the most prominent ore mineral, but chalcopyrite and pyrite are generally more abundant, and the ore may carry several ounces of gold per ton. These lodes have been best explored toward the north, where some of them form junctions with the Silver Lake lode. Several of them pinch and die out in a few small, irregular stringers before reaching this fissure. Others, such as the New York City and Royal veins, reach and connect with the master lode. The general relations of the lodes of the two groups can perhaps be best understood from fig. 2, page 51, which is a generalized and diagrammatic sketch of the plan of the principal fissures exploited in the Silver Lake and Iowa mines, on the west side of Silver Lake. The Silver Lake lode is fully as long again as shown. It has been exploited on the northwest through the old Nevada mine and is known to extend into the head of Blair Gulch. Toward the southeast it passes under the lake and is probably continuous with the lode of the Royal Tiger mine. Just before crossing the southeast rim of the basin, the Tiger lode divides into two branches, neither of which has been traced far beyond the point of divergence. A plat of the principal claims of Silver Lake Basin and vicinity is shown in Pl. XIII.

As the lodes of the second group approach the junction with the Silver Lake vein they become poor. Their courses are also deflected toward the west, as indicated in the sketch. The country rock in the V near the junction is usually shattered and traversed by numerous quartz stringers. Some of these are irregular, but there is often noticeable a radiation of the stringers outward from the angle of junction. In some instances a breccia has resulted, the fragments being cemented by quartz and themselves altered into aggregates of quartz, sericite, and other secondary products by the action of the vein solutions. A close study of all exposures of such conjugations of the veins of the two groups failed to show any evidence of different age. The filling of both sets of veins is continuous, as it would be in synchronously filled branches of a single fissure, or is separated by a clay gouge due to subsequent movement. As far as is known, there is no continuation of the lodes of the second group north of the Silver Lake lode. A single small vein (the Jim Owen), shown in fig. 2, has been prospected for a short distance northward from the Silver Lake lode, but it is very improbable that this represents the continuation of any of the productive lodes south of the latter. If the Silver Lake lode were, as is supposed by the miners, younger than the lodes of the second group, the absence of the latter on the northern side of the intersecting lode could be accounted for only on the assumption that the Silver Lake fissure is a fault of at least 2,500 feet throw. The entire evidence of the region, however, as is elsewhere shown, indicates that the fissures now occupied by productive ore bodies were not formed by large faults, but on the contrary often reveal no appreciable displacement of their walls.

The relation of the lodes of the second group to the great Titusville lode on the south are not so well known as in the case of the Silver Lake lode on the north. The lodes in this portion of the basin are imperfectly exposed and have received very little underground exploration.

The ore bodies of the lodes of Group II have not been worked in such a manner as to give any very definite data as to their dimensions and shapes. In nearly every slope considerable masses remain which are regarded as pay ore. The pay shoots are supposed to pitch northward, but it is by no means certain that there is any regularity in their pitch.

In addition to the main lodes a great number of smaller fissures traverse the country rock, particularly west of the lake. The strike of these minor veins ranges from 20° to 40° west of north. They are nearly vertical, but one group of them sometimes exhibits a steep northeasterly dip, while another group dips southwesterly. The latter case appears to be more common. They are often so closely spaced, a few feet apart, as to produce a conspicuous sheeting of the country rock. This spacing does not exhibit any regularity or recognizable rhythm in its occurrence. Many of these fissures are ore bearing, and it is not uncommon to see on a clean exposure of rock a stringer, an inch or so wide, consisting of quartz next the walls and solid galena in the medial portion. Such mineralized stringers can be seen to branch or to wedge out completely in the rock and be succeeded by an overlapping stringer a short distance to one side. On a small scale they repeat the phenomena to be observed underground in the larger veins of the second group. They are believed to belong to the same system and to have been formed at the same time as the latter.

Although the lodes of the Silver Lake Basin have been classified in two groups, it should be borne in mind that the distinctions upon which the grouping is based are quantitative rather than qualitative. The difference in direction, sufficiently marked and definite on the west side of the lake, becomes less so on the east side, where the Silver Lake lode appears to begin splitting up into its ultimate ramifications. Moreover, as will appear when the separate mines are described, the general difference in the ores of the two groups is a difference in value rather than in mineralogical type, and is neither constant nor without exceptions.

It is fairly certain that the original formation of the fissures of Silver Lake Basin was unaccompanied by any considerable faulting. A careful study of all the available underground workings and of the surface geology and topography of the basin has failed to reveal the existence of any extensive tangential movement (faulting) along the vein fissures. Moreover, if the mutual relationship of the lodes has been correctly interpreted, it would seem that the conception, very commonly held, that vein-filled fissures are produced essentially by faulting involving considerable tangential movement, and usually by thrust faults, is inapplicable as an explanation in the present case. The more general aspects of this subject are discussed under the head of "The lode fissures," on pages 43–63.

Silver Lake mine.—This, the most extensively developed mine within the quadrangle, is situated at an altitude of about 12,300 feet, with its principal adit near the western edge of Silver Lake. As is frequently the case, it includes a number of individual claims, some of which, such as the Whale, were separately worked in former days and produced considerable ore. Prior to 1881, the Whale, Silver Lake, Round Mountain, and other claims now embraced in the Silver Lake mine had attracted but slight attention. In 1882 a little ore was produced, which is said to have carried 50 ounces of silver and 60 per cent of lead. In 1883, 72 tons of ore, containing 28 ounces of silver per ton and 55 per cent of lead, were shipped to Sweet's Sampling Works in Silverton, and the Silver Lake claim, with its 55 feet of drifting, was regarded as a promising prospect. Since then its development has progressed with rapid strides. In 1891 the mine was credited in the Mint reports with a product of $254,908.

At least six distinct lodes have been worked, and the vertical distance from the uppermost to the lowermost stopes is somewhat over 1,000 feet. The main adit is a crosscut for about 250 feet. It then follows the Silver Lake lode northwesterly for about 1,000 feet. Thence a crosscut to the southwest, some 900 feet in length, gives access to the various lodes of the second group, viz, the L. A. S., E. G. S., Royal, Stelzner, and New York City lodes. A northwesterly drift along the New York City lode for about 1,250 feet again comes into the Silver Lake lode, and from this junction a drift of about 400 feet runs out to the surface in Whale Basin, on the west side of

Round Mountain. In addition, the Unity tunnel, run in from the southwest side of Arrastra Gulch, cuts the Silver Lake and New York City lodes 700 feet below the present main adit level (No. 1). Still a third tunnel is being run in a southeasterly direction from a point near the Animas River, at the mouth of Blair Gulch, which will, if carried through, ultimately tap the Silver Lake lodes at the lowest practicable point, over 2,500 feet below the No. 1 level.

There are no abandoned workings, and the character and relationships of the lodes may be studied under more than usually advantageous circumstances.

The Silver Lake lode as exposed in the mine has a general strike of N. 53° W. Its dip is to the northeast and varies from 50° to 70°—the flatter dip being more common in the upper workings. The average dip is probably a little over 60°. Its croppings are conspicuous as a rust-colored zone of oxidation running up the declivity west of the lake and passing through the col just south of Round Mountain. At this point they have an apparent width of about 40 feet of stained and cellular quartz carrying galena, as well as the carbonate and sulphate of lead. Northwestward from this saddle the lode, different portions of which are known as the Round Mountain, Lowville, and Nevada lodes, crosses Whale Basin just above the cliffs of Arrastra Gulch, and passes through another saddle into the head of Blair Gulch. In its productive portions the Silver Lake lode is from 6 to 20 feet in width. Elsewhere it may be represented by a strong clay seam or gouge, or less commonly a small tight vein. The filling of the fissure is quartz, carrying variable amounts of galena, sphalerite, chalcopyrite, and pyrite. No regular arrangement of the ore minerals within the quartz could be detected. They occur in irregular bunches in all portions of the vein, and appear to be the result of a single uninterrupted process of deposition. The ore bodies, also, although often of considerable size, are without any known regularity in their distribution through the lode. The best ore is usually found in the more solid portions of the lode, a soft lode with abundant gouge being regarded as less favorable. The ore is nearly always separated from the walls by more or less gouge. A sheeting of the walls parallel with the main fissure is not infrequent, and where it occurs careful prospecting is necessary to avoid overlooking considerable masses of ore which may be lying behind what appears at the time to be the outer wall of the lode. On levels 1 and A the most productive portion of the Silver Lake lode is divided into two branches by a large horse of country rock traversed by stringers of quartz.

In the levels above No. 1, particularly in level 4, the Silver Lake vein is frequently a soft yellowish mass of more or less broken quartz, decomposed country rock, clay, cerussite, and other products of alteration. This portion of the lode thus shows considerable oxidation, particularly where there is evidence, in the form of clay seams and crushing of the quartz, of movement since the deposition of the ore.

Anglesite and cerussite were found associated with the galena in these upper levels, but never formed a very large proportion of the ore, of which the important bodies, even in these upper workings, were chiefly galena.

Movements within the Silver Lake lode subsequent to the deposition of the ore may be conveniently divided into four classes, (1) faults cutting the lode obliquely and at a considerable angle with the horizontal; (2) strike faults essentially parallel with the lode; (3) strike faults making a considerable angle with the plane of the lode, and (4) irregular fracturing. Those of class 1 will first be described.

(1) A close inspection of the southwest or foot wall of the Silver Lake vein shows that it is cut at frequent although irregular intervals by fissures, usually of small width. It is seldom possible in such cases to determine accurately the general course of these fissures. Fissures are never geometrical planes, and an observation made on a fissure exposed in the walls of a drift may give figures differing very much from the general or average course of the dislocation. The observed courses of these fissures give directions varying from north and south to N. 55° W. In general, they appear to form a system essentially parallel with the productive lodes of Group II, such as the New York City and Royal. Their dip is usually to the southwest at a high angle (over 70°), but there are a few notable exceptions. The fissures vary from narrow cracks up to openings a foot wide. In a few cases they are filled with solid quartz, carrying a little ore. These last are not known to cut the Silver Lake lode. They are probably of the same age as the latter and are comparable, in all respects save size, with such veins as the E. G. S. and L. A. S. of Group II. Most of these fissures, however, are filled with a clay seam or gouge of varying thickness, sometimes containing broken vein quartz. These fissures cut through the Silver Lake lode and are therefore younger. They record disturbance subsequent to its formation. They have not influenced the productiveness of the latter to any known extent, but are well known and carefully watched by the miners on account of their misleading tendency. Experience has shown that a miner, on running upon one of these cross seams, is very likely to follow it into the hanging wall, leaving, unknowingly, the main lode on his left. The presence of broken quartz mixed with the gouge of these seams shows that in some cases they record fresh movement along preexisting fissures which had become filled with quartz. The actual result of movement along these post-mineral fractures is present as gouge, but the net displacement seems to have been always small. It is usually impossible to detect any actual faulting of the main lode where crossed by these later fissures.

On Level A, southeast drift, a set of fissures occurs which, while apparently belonging to this system, are of unusually flat dip, in one case as low as 20°. The direction of dip is easterly. The vein itself is very irregular southeast of the first of these faults and is chiefly a breccia of country rock cemented by quartz and low-grade ore. It is such an irregularity as might be expected near the lower edge of the large horse which divides the lode on this level and the one above.

(2) Strike faults, essentially parallel with the lode, are more conspicuous in the case of the Silver Lake than in the other lodes of the mine. They are indicated by gouges, often of considerable thickness, on foot or hanging-wall, and by sheeting of the country rock when accompanied by soft gouge. Their effect upon the lode is well seen near the northwest end of level 2, where there is a pronounced strike fault on the hanging-wall side of the vein associated with approximately parallel slips within the country rock of the hanging wall. The lode here is crushed and contains much clayey gouge. The character and amount of the movement could not be determined in any case. It is believed, however, to have been in the main oscillatory, with but little net displacement. Had it been otherwise it would be very difficult to account for the present relation of the Silver Lake lode to the lodes of Group II and for the absence of gouge or other evidence of recent movement in certain portions of the former lode.

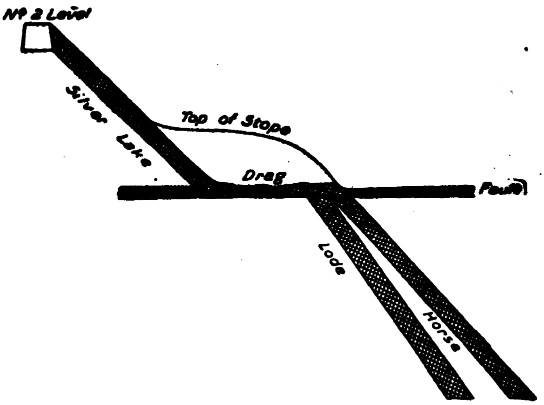


FIG. 11.—Sketch section across the Silver Lake lode between levels 1 and 2, showing probable faulting of the lode by a flat strike fault.

(3) Strike faults making a considerable angle with the plane of the lode are not common on the Silver Lake lode. The best example of this form of dislocation was noted in a large stope between levels 1 and 2. The fault here is nearly horizontal and cuts both branches of the Silver Lake lode near the apex of the horse which divides them. The dislocation is a thrust fault with about 12 feet throw. The character of the fault and its result upon the ore body are shown by the accompanying sketch section across the stope (fig. 11). This fault appears to die out within a comparatively short distance to the southwest, as it was not noted on the stopes of the Royal and Stelzner lodes.

(4) Irregular fracturing of the lode includes those minor dislocations which it has not been found possible to group according to any prevailing regularity of direction. They are often directly connected with the more regular fissures and are of small importance.

The ore of the Silver Lake lode is low grade, carrying very little gold. Although it has been extensively stoped in the past, the main output of the mine is from the lodes of the second group.

The New York City vein (or Whale-Rochester vein) is the most important of these, from the extent, regularity, and comparatively high grade of its ore body. Its general strike is about N. 20° W., and its average dip is about 80° to the northeast. As to the Whale-Rochester vein, its upper portions were formerly extensively worked through an adit in Whale Basin. In the Silver Lake mine it has been worked through levels 1 and C, 300 feet apart, and by means of an intermediate level halfway between them. This lode is generally smaller than the Silver Lake, and has been less disturbed by post-mineral movement. The ore is generally fast, or frozen, to the walls, and is usually solid and unoxidized. In common with the other lodes of Group II the New York sometimes pinches to a very narrow and tight seam. This is well illustrated at the point where it is intersected by the crosscut on level C. It is here a stringer less than an inch in width, showing little indication of being part of a great productive vein. The chief value of the New York City vein has been found to lie northwest of the points where it is pierced by the crosscuts on levels 1 and C. In this direction it is stoped practically continuously up to the Silver Lake lode. A typical section of the lode from the stope above level 1 is shown in fig. 3, page 67. As it approaches the Silver Lake lode it becomes smaller and more irregular, and bends westward. It is also somewhat oxidized and stained. At the junction it passes into the Silver Lake with no other lines of separation than those due to later movement, and is usually defined by seams of gouge. From the point of junction westward the ore of the Silver Lake vein contains more chalcopyrite than is usual elsewhere, and thus resembles somewhat the ore of the New York City vein. The productive portion of the New York City vein is cut by a fault about 750 feet south of its junction with the Silver Lake vein. The strike of this fault is apparently about N. 73° E., and it hades northerly about 15°. It has thrown the northern portion of the lode from 12 to 15 feet to the west. This fault was best seen in the stope above the midway level. Here the vein is cut off abruptly by a breccia zone about 6 feet wide which crosses the stope. The breccia is composed of sharply angular fragments of country rock cemented by quartz, which carries a little ore, but is of too low grade to pay. Within the breccia zone are two or three fairly regular quartz stringers. This occurrence is of special interest as showing that the deposition of quartz and ore was not confined to the period within which the important lodes were filled, but also took place at a later time. On the other hand, it seems very probable that this fault is older than the faults usually filled with soft, moist gouge, which have been described in connection with the Silver Lake vein. South of the crosscuts the New York City lode has proved of little value. This portion of it has obviously been subjected to strong disturbance connected with a pronounced zone of post-mineral faulting. This fault appears to have a general north-and-south strike, and hades to the east about 20°. Where it is cut by the crosscut on level 1, about 140 feet east of the New York vein, it shows a zone of broken and disturbed country rock about 12 feet wide, with a strong gouge on the hanging wall. This zone of disturbance appears to intersect the New York City lode about 200 feet south of the crosscut. The lode and the adjacent country rock have been broken up, and the value of the former has been destroyed. The country rock is traversed by seams of soft, moist gouge, in general parallel with the line of the fault, but often showing considerable irregularity. Small bunches and stringers of ore are found, but they are not continuous. On level C what is supposed to be the same fault crosses the crosscut about 330 feet east of the New York lode. It is here less than 6 feet wide, and is composed of broken, decomposed country rock and wet clay gouge. As on level 1, the New York lode has so far proved worthless south of the crosscut. The New York lode, probably originally somewhat irregular south of the crosscut, has been dislocated by a fault cutting it at a small angle and thus producing somewhat the effect of a strike fault parallel with the vein. The direction and amount of movement along this fault are not known. Some light may be thrown on it when the Silver Lake lode, which it should cut, is more thoroughly opened up. If any undisturbed ore bodies exist in the southern part of the New York lode they probably lie east of the present south drift on level 1.

In the autumn of 1899 the crosscut driven to cut the New York lode from the Unity tunnel, 400 feet below level C, had overshot its objective, and upon searching back the New York was found at the beginning of the crosscut near the Silver Lake lode. This was opened by a short drift and found to carry a body of excellent ore similar to that of the upper levels.

The ore of the New York City lode consists of galena, sphalerite, chalcopyrite, and pyrite in a quartz gangue. Some of the richest ore occurs in a rather friable stringer near the foot wall, which contains black oxide of copper (melaconite), with considerable chalcopyrite and pyrite. This may carry several ounces in gold, although free gold is very rarely seen. It is worth noting that the melaconite is found in the deepest workings, level C, at least 700 feet below the surface.

The Stelzner and Royal veins resemble in their general characters the New York City. The course of the Stelzner is rather curving and irregular, but may be generalized as about N. 20° W. That of the Royal is about N. 35° W. It thus nearly bisects the angle between *the Stelzner* and Silver Lake and illustrates the essentially radial *character* of the whole group of lodes. This feature is still further brought out by the fact that the Stelzner and the Royal with its two branches, called the right-hand and left-hand Royals, are, in the lower levels, all ramifications of a single vein, which in turn is a branch of the Silver Lake lode. Both the Royal and the Stelzner veins dip to the northeast. The Royal is very nearly vertical, while the Stelzner has an average dip of 75° to 80°. Consequently the line in which the two lodes join pitches southeastward. On the other hand, the much flatter dip of the Silver Lake lode causes the lines of junction between it and the veins of Group II to pitch to the northwest. As a result of these conditions the Stelzner and Royal join the Silver Lake on level 4 as separate veins. On level 3 the Stelzner, Royal, and Silver Lake lodes all come together at about the same point. On level 1, however, the two veins unite about 200 feet before they join the Silver Lake lode as a single vein. The junction of the Royal-Stelzner vein with the Silver Lake is similar to that described in the case of the New York lode. On level 2, at the point where the two veins come together, no clay seam could be seen separating them, although a little farther northwest the Silver Lake lode shows well-marked seams of soft, wet gouge on foot and hanging walls. At the junction there is much brecciated country rock, cemented by quartz which is full of small vugs.

On level B, north drift, the combined Royal-Stelzner vein has been stoped for about 400 feet, to a point where the lode diminishes to a small stringer. A short crosscut to the west, however, discovered the continuation of the lode. There is apparently no fault at this point. The lode has merely pinched out and is succeeded by a slightly overlapping parallel fissure in the manner already described.

The productive portions of the Stelzner vein are sometimes 10 or 12 feet in width. The Royal is usually somewhat narrower. The ore in both veins is usually solid and not accompanied by any considerable gouge. Post-mineral movement along the fissures is not, however, wholly lacking, and is best seen where the veins pinch to very narrow dimensions. As usual, in this mine the country rock near the veins has not undergone any alteration which can be recognized by the eye as evident and characteristic. The ore of the Stelzner and Royal veins consists of abundant galena, with sphalerite, chalcopyrite, and pyrite in a gangue of quartz. A little dolomite occurs in the vein, usually associated with included fragments of country rock. The quartz also shows greenish patches of chlorite, which are regarded as an indication of good ore. Chalcopyrite is less abundant than in the New York vein. The ore may carry 2 or 3 ounces of gold and is of higher grade than that of the Silver Lake lode, although somewhat inferior as a whole to the ore of the New York vein.

The E. G. S. is a small vein approximately parallel with the Royal and lying about 60 feet to the northeast of it. In its general character it resembles the Stelzner and Royal, but is smaller. Its junction with the Silver Lake can be seen on level 2. At the junction the quartz of the two lodes is separated by a narrow seam of gouge. Together they constitute a solid vein of low-grade ore about 10 feet wide. The E. G. S. has contained some of the richest pockets of ore encountered in the mine, but its value falls off, like the other veins of Group II, as it approaches the Silver Lake. The L. A. S. is another similar small vein, which was not worth working until level B was reached. It illustrates the fact, thus far exemplified in this mine, that the small veins of Group II may prove more valuable and have longer ore bodies as they are worked downward and as their junctions with the Silver Lake are carried farther and farther to the northeast on account of the relatively flat dip of the latter lode.

The Silver Lake mine is worked by overhand stoping, the ore being broken down onto canvas, and the stopes are filled with waste as the work is carried up. Siemens and Halske electric drills are used in most of the stopes. They are portable and convenient, but somewhat too lightly constructed for the work required of them. The ore from the various levels is all dumped into bins at the central station on level 1, that from the lower levels being raised through a vertical shaft by a cage and an electric hoist. From the central station the ore is drawn out in trains of cars by mules to the mill at the mouth of the adit.

At the mill it is sorted, the larger and heavier pieces of nearly solid ore being sent down the tramway as crude, or shipping, ore. The equipment of the mill is 2 Blake crushers, 50 stamps, 4 sets of rolls, 10 Wilfley tables, 8 Hartz jigs, 8 Woodbury tables, and 18 "end-shake" slime tables. Power is furnished by three 100-horsepower boilers and a 150-horsepower engine, and the mill has a daily capacity of about 200 tons. The water for milling is pumped from the lake, into which the tailings are allowed to run at another point. A new mill is now in progress of erection on the Animas River, at the lower terminal of the tramway.

As already stated, the ore of the mine is low grade. Ore running $10 a ton can be worked, but even $8 ore is often run through the mill with the better grades. About half the total value of the output is in gold, the rest being in silver, lead, and copper. Free gold is very rarely seen, and no attempt is made at amalgamation. The concentrates are said to average about $45 per ton. The crude ore and concentrates are carried down from the mill on a substantially constructed Bleichert tramway to a large terminal station near the mouth of Arrastra Gulch, furnished with capacious bins. From these bins the ore is loaded directly onto the railroad cars. A second tramway from the Unity tunnel was completed in October, 1900, and will soon handle the bulk of the ore.

Power for hoisting, pumping, and lighting the mine and buildings is generated by dynamos run by two Pelton waterwheels located on the Animas opposite the mouth of Boulder Gulch, the water for this purpose being taken from the Animas River just below Howardsville. In 1900 a substantial plant was also being installed at the same place for generating power by steam.

Iowa mine.—The Iowa mine also lies on the west side of Silver Lake and joins the Silver Lake property on the south. A prospect in 1881, its growth has, in a general way, followed that of its larger neighbor. The principal development has been on the Iowa, East Iowa, Stelzner, and Melville lodes. The last is probably continuous with the Black Diamond-Royal lode, but has not proved profitable in the Iowa mine, as it has in the Silver Lake ground. Practically all of the stoping has been on the Iowa, East Iowa, and Stelzner lodes. The relation of these three lodes, as shown in fig. 2 (p. 51), illustrates admirably the arrangement of veins en echelon, as observed in the small ore-bearing stringers on the surface. The Stelzner lode becomes small and poor at its southern end and is succeeded on the west by the overlapping East Iowa lode, which in turn is similarly succeeded by the Iowa lode. The Iowa and East Iowa lodes can be seen to die out in a few small stringers toward the north. That they actually terminate as individual lodes and do not open out again still farther northwest is shown by the fact that no lodes corresponding to them have been found in the two long crosscuts to the New York vein in the Silver Lake mine. Similarly, any southeasterly extension of the Stelzner and East Iowa should have been noted in the crosscuts of the Iowa workings. A lode plan such as is here described is not consistent with any extensive faulting along the lines of the fissures.

The Iowa has been worked on four levels, connecting with the surface by adit tunnels. They are numbered from above down. Work at present is confined to levels 3 and 4. The distance between levels is not uniform. Thus from level 1 to level 2 is 100 feet; from level 2 to level 3, 200 feet; and from level 3 to level 4, 130 feet.

The best ore in the mine occurs in the Stelzner vein and is identical with that already described in the Silver Lake workings. It may carry 2 or 3 ounces of gold. The ore of the Iowa and East Iowa lodes is a heavy lead ore carrying little gold, and resembling the ore of the Silver Lake lode more than is usual in the veins of the second group.

The main Iowa vein varies in width in its productive portions up to 15 feet. It is commonly between 2 and 5 feet wide. It dips steeply to the northeast, the average angle being near 80°. It is a generally simple and regular fissure vein, with well-defined walls. At its best it consists of nearly solid galena, with some quartz, chalcopyrite, sphalerite, pyrite, and chlorite. Comb structure is occasionally shown in the quartzose portions of the vein, and irregular vugs occur lined with crystals of quartz and galena. The galena sometimes occurs chiefly in the middle portion of the vein, as if it were of later crystallization than the quartz. In many cases, however, it is scattered through the vein in bunches without any apparent regularity.

The vein filling is solid and shows very little trace of movement su sequent to the deposition of the ore. It generally lies close again the walls of the fissure, with little or no gouge. As in the Silver Lak mine, the wall rock does not, as a rule, exhibit any very marked alter tion close to the vein. The microscope shows, however, in the roc alongside the vein a thorough recrystallization of the original roc constituents into aggregates of quartz and sericite, with some calcit and specks of pyrite. A specimen 10 inches from the vein show similar alterations, but with more calcite and abundant chlorite. Th same general character of alteration is found 2 feet from the vein. A 50 feet from the vein quartz, chlorite, and calcite make up most o the rock, in which traces of the original structure remain, and th sericite is confined chiefly to the altered feldspar phenocrysts.

The Stelzner lode presents the same characteristics in the Iowa min as in the Silver Lake. It is a nearly solid, simple vein, showing a much as 8 feet of excellent ore in the stopes. There is usually n gouge between the vein filling and the walls.

The East Iowa vein has not proved of very great importance. I has been stoped for a distance of over 100 feet, but presents no feature of special interest.

The Melville lode is chiefly notable from the fact that in its south ern portion it dips to the southwest at from 70° to 75°. It carrie galena, sphalerite, chalcopyrite, and pyrite in a gangue of quartz with a little barite. It varies in width, being in some places as muc as 4 feet wide. The ore is too poor to work. Northward this vei becomes irregular and in places is a nearly vertical fissure containin some gouge, but no quartz. It finally dies out in a few barren string ers. Although in general line with the Black Diamond-Royal lode, i is by no means certain that it occupies the same fissure. The lo grade of its ore and its westerly dip, contrasted with the good ore an steep easterly dip of the Royal, seem rather to indicate that it is a overlapping fissure, bearing a similar relation to the Royal that th East Iowa does to the Stelzner.

Regular parallel fissuring of the country rock, the fissures bein usually filled by stringers of quartz and ore, is even more conspicuou in the Iowa than in the Silver Lake mine. As in the latter mine these fissures are apparently minor results of the same forces tha produced the productive veins of Group II, seeming, in fact, to belon to that group. In the Iowa these fissures usually dip very steeply t the southwest.

Generally the lodes in the Iowa are very regular in their productiv portions, having comparatively few horses. The ore is confine within the fissure walls. The disturbance and movement which ha taken place since the veins were formed is scarcely appreciabl Tetrahedrite is reported as occurring in the Iowa workings, but non was seen at the time of visit.

The Iowa ore is carried on a Bleichert tramway, built in 1897, down to a mill situated in Arrastra Gulch, about a mile from its mouth. In 1899 an additional tramway was built from the mill to the railroad, on the Animas River. As a whole the ore is of low grade, averaging from $10 to $14 a ton, and carrying a large proportion of lead. The mill is equipped with 1 9 by 15 Blake crusher, 2 sets 14 by 27 rolls, 7 3-compartment jigs, 2 5-foot Huntingtons, 1 5-foot Chilian mill, and 5 Wilfley and 8 Cammett tables. The power is steam, and the daily capacity of the mill is given as from 175 to 200 tons of crude ore.

Royal Tiger mine.—This property, which is in the early stages of development, is on the east side of Silver Lake, and is supposed to be on the continuation of the Silver Lake lode. This, indeed, seems probable, although it is by no means certain, as there are too many nearly parallel veins in this vicinity to permit offhand correlation across the width of the lake. The Tiger lode, moreover, presents several characters foreign to the Silver Lake lode as exploited on the west side of the lake, and may fill an overlapping fissure nearly in line with the latter. The main adit is a crosscut at an elevation of 135 feet above the lake, and the levels are numbered from this upward. A little stoping has been done on level 4, but the bulk of the work has been on levels 2 and 3.

The lode dips steeply northeast, the average being nearly 80°. Locally, however, it may sometimes have a steep southwesterly dip, as on level 2, about 400 feet from the entrance of the tunnel. The width of the lode varies up to about 10 feet. It is usually fairly regular, but sometimes pinches for considerable distances, showing crushed rock accompanied by gouge, but very little ore. Near the entrance to level 2 the lode is divided by a horse 30 or 40 feet in width. Both branches of the lode come together in the stope above this level, where the lode shows about 19 feet of low-grade milling ore. It here takes on the character of a stringer lead, consisting of a network of stringers with much shattered country rock. The lode in this stope shows no gouge and no regular walls, the stringers running out irregularly into the country rock. Some of the ore-bearing stringers were faulted by later stringers of barren quartz. Small vugs, lined with quartz crystals, are frequent. The Tiger lode is frequently free from gouge and often without well-defined walls. In such cases the country rock near the lode is intersected by stringers and may carry bunches of ore. In other places there may be clay gouge on foot or hanging wall, or both, and even within the lode itself. Thus, movement subsequent to deposition of the ore has affected some portions of the lode, but not others.

The mine produces essentially a lead ore carrying from 20 to 60 per cent lead, rarely more than 12 ounces of silver, and occasionally a little gold—up to half an ounce. One specimen of free gold has been found. The gold usually occurs associated with sphalerite and chalcopyrite. The chief ore mineral is galena, which is accompanied by sphalerite and a little tetrahedrite and chalcopyrite. The tetrahedrite was most abundant in level 6, near the top of the ridge. It occurs in the lower levels, but less abundantly. The gangue of the ore is quartz with some barite. The quartz and galena are crystallized together irregularly in the larger stringers and in the main lode. A little native copper has been found on level 3. The alteration of the wall rock adjacent to the lode is somewhat more noticeable in the Tiger than in the other mines of the Silver Lake Basin. A specimen from the south wall of level 3, about 3 feet from the main ore body, is a compact, light greenish-gray rock, showing indistinct traces of former porphyritic structure. It is traversed by numerous veinlets. The largest of these, about one-fourth inch wide, carries quartz, galena, and sphalerite. This veinlet shows comb structure, and the ore minerals tend to crystallize along the medial line. Smaller veinlets consist of galena without quartz. The rock itself is thickly speckled with minute crystals of pyrite. Under the microscope the rock shows the general structure of an andesite, but no remnant of the original minerals remains. The feldspars are changed to aggregates of quartz and sericite, and the same minerals, very finely crystalline, seem to compose the entire mass of the rock, exclusive of the thickly sprinkled pyrite.

In the breast of the drift, level 4, the lode, which is about 4 feet wide, contains a dark horse-like mass. This is said to have been 4 feet wide in places and to carry 1 to 2 ounces in gold. This material shows numerous white spots, which suggest altered feldspathic phenocrysts, lying in a dark-gray groundmass. The whole is mineralized, and contains specks of galena, sphalerite, chalcopyrite, and finely crystalline pyrite. Under the microscope fragments showing the structure of an andesitic rock are seen embedded in a matrix of quartz and a very finely crystalline material, which is apparently kaolin, although there seems to be some sericite present also. The andesite fragments are altered to aggregates of these same minerals, but preserve their original porphyritic structure. The material is a much altered and mineralized breccia, but whether an original tuff-breccia or a breccia formed during the formation of the fissure it is impossible to say. The lode at this point shows indications of some brecciation of the ore and subsequent cementation by barren white quartz.

The Royal Tiger mine has not yet a separate mill. It is connected with the Iowa mine by a wire tram across the lake, and the ore is sent down to the Iowa mill. Although extensive work had barely begun in 1899, in 1900 the Royal Tiger was producing more ore than the Iowa.

Buckeye mine.—This mine, situated about one-third of a mile south of the lake, is on the Titusville lode. Work on it was abandoned some years ago, but the old tunnels were being cleaned out and reopened in 1899. The ore is chiefly galena, with some tetrahedrite, the latter being more abundant in the upper tunnel. There is no mill at this mine, and the ore was formerly packed out on burros.

Titusville mine, at the head of Kendall Gulch, although not in Silver Lake Basin, may be most appropriately mentioned here as being on the same great lode as the Buckeye. This mine was first worked about 1886. A small mill was subsequently erected in Kendall Gulch, and the ore was carried down on a lightly constructed Huson tramway about 8,000 feet in length. The mine ceased operating in 1893. It was developed on four levels, aggregating about 1,150 feet of drifts. The lode is about 30 feet wide. Its general dip is to the northeast at about 80°, although it is locally vertical. It consists of chalcopyrite, galena, sphalerite, and pyrite, in a gangue of quartz and rhodochrosite. Chalcopyrite is the most abundant ore mineral. The ore is generally of low grade, that containing abundant chalcopyrite running about $6 per ton. There is a richer streak, however, usually about 14 inches wide, which may run as high as $30 per ton. Some of this richer ore contains very finely crystalline galena scattered through the quartz in minute particles. Where this occurs the ore may carry from 1 to 3 ounces of gold and 60 to 100 ounces of silver per ton, the value being associated with the presence of the galena. The product of the Titusville mine in 1888 was $51,300.

From this mine the lode can be traced over the slope to the summit of Kendall Mountain, where it appears to divide. It has been prospected along this distance on the Seymour, Emma, Pyramid, Pompeii, and Sal Custer claims, and some ore has been taken out, chiefly galena. On the west slope of Kendall Mountain, the Idaho prospect, in Silverton Gulch, is apparently on the same fissure or fissure zone, although it is here very different in character. The country rock at this point is monzonite, part of the great stock of Sultan Mountain. The vein here is usually without gouge and narrow—18 inches or less. It dips southwesterly about 80°. The ore is mostly chalcopyrite and pyrite, with pockets of galena in a quartz gangue. The galena usually occurs in the middle of the vein, with quartz, chalcopyrite, and pyrite on the sides. This prospect has been worked intermittently for twenty years and has produced some ore. The development consists of two tunnels and some small stopes.

LODES OF HAZELTON MOUNTAIN.

General.—Hazelton Mountain, as the spur separating Blair and Arrastra gulches is called, was the scene of some of the earliest mining in the quadrangle. In 1874 work was already in progress on the Aspen, Prospector, Susquehanna, Mammoth, and other claims, most of which were afterwards consolidated as the Aspen mine.

Aspen mine.—The workings of this mine, which are extensive, are shown in plan and longitudinal section in fig. 12. As early as 1875, the Susquehanna and Aspen claims were being worked at a profit, while in 1876 the Prospector lode was developed by two shafts, 100 and 130 feet deep, connected by a drift 100 feet long. The product of the group up to 1880 has been estimated at over $200,000. In 1882 the Aspen group, embracing the Aspen, Susquehanna, Mammoth, Legal Tender, Matchless, and McGregor claims, was one of the best developed properties in the district and had over 5,000 feet of workings. During this year its operators contracted to furnish Sweet & Co., in Silverton, with 3,000 tons of ore, which were crushed, sampled, and sent to the new smelter in Durango. In 1893 the Mint reports credit the mine with a product of $75,000, and in 1897, $78,000. In 1892 the output, according to the same authority, was $50,916. In all, 11,423 tons of ore have been produced since January 1, 1884.

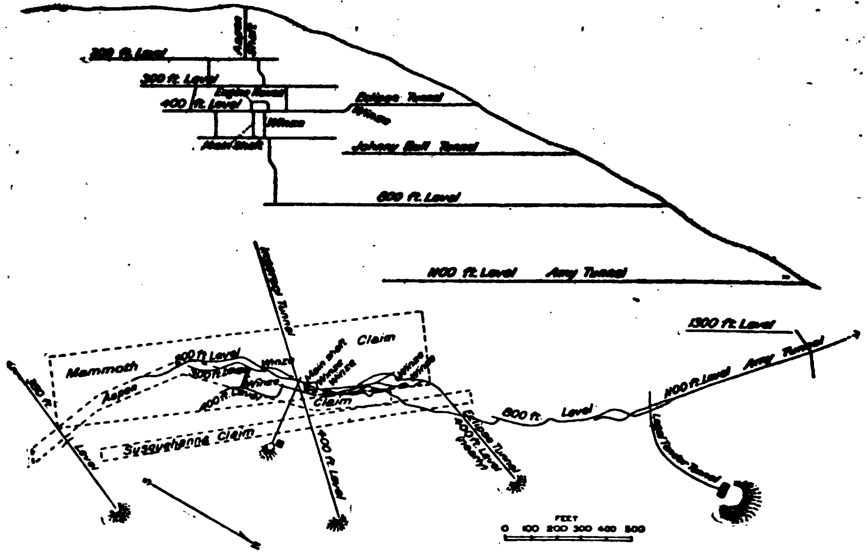


FIG. 12.—Plan and longitudinal section of the workings of the Aspen mine, Hazelton Mountain.

As the mine has been idle for several years, it was impracticable in 1899 to make a satisfactory study of its underground workings. In 1900, however, some progress had been made toward opening or retimbering the Amy tunnel, connecting with the 800-foot level. Access to a small portion of the lode was obtained through the Legal Tender tunnel. The vein at the point cut by the tunnel strikes N. 50° W. and dips southwest at about 80°. It is small at this place, accompanied by soft gouge and disturbed by some cross faulting. The Legal Tender tunnel shows the country rock to be traversed by several other veins running generally parallel to the Aspen.

The Aspen workings are in rocks belonging to the Silverton series, exhibiting chiefly the characteristic breccia structure already described and containing much rock of rhyolitic character. The lowest tunnel, which, judging from the dump, has not cut the lode, is in massive andesite.

According to information received from W. H. Thomas, there were several small veins near the surface, which came together in the deeper workings. The plan of the workings (fig. 12) indicates that the lode is of rather irregular character and that the general dip is northeasterly, at angles varying from 40° to vertical. It is often assumed that the Aspen lode is the northwestern continuation of that branch of the North Star lode upon which are located the Slide and Mayflower claims. But, as elsewhere pointed out, it is more likely that they are distinct.

The ore of the Aspen is chiefly a heavy lead-silver ore, consisting of galena, sphalerite, chalcopyrite, pyrite, tetrahedrite, and a little native silver in the upper workings. The gangue is quartz, with considerable green fluorite. The tetrahedrite is said to have occurred in pockets or bunches in the other ore minerals. One trial lot of ore, consisting of 1,000 tons, is reported to have run 110 ounces of silver and 60 per cent of lead, no returns being made for gold. The Aspen ore was smelted in the old Greene smelter, north of Silverton, as long as that pioneer plant was in operation.

It is commonly stated that the Aspen ceased working on account of the poverty of the ore in the lowest workings. It is probable, however, that good bodies of ore will yet be found, and that the mine will again become productive.

NORTH STAR[1] (KING SOLOMON) GROUP OF LODES.

General.—The prominent North Star lode crosses Little Giant Peak, northeast of Silver Lake Basin, very near its summit. Its general course is a little more northerly than that of the Silver Lake vein, or about N. 48° W. The dip is northeasterly, but nearly vertical. Northwest of the peak the lode continues through the Terrible, Slide, Mayflower, and Argentine claims, down into Arrastra Gulch. It is often supposed that the Grey Eagle-Aspen lode, on the south side of Arrastra Gulch, is part of the North Star lode. But the connection, if it exists, which is doubtful, is concealed by the talus in the gulch. It seems more probable that the Aspen is a distinct, essentially parallel, overlapping lode. Southeast of Little Giant Peak the North Star lode continues through the Dives, Shenandoah, Mountaineer, and Lookout claims into Mountaineer Gulch.

North Star (King Solomon) mine.—This mine was first regularly worked in 1883, although it had been exploited intermittently for three or four years previous to that time. Since then it has been producing steadily up to a year or two ago. The total product since 1883

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[1] There are two North Star mines within the quadrangle—one on Little Giant Peak, commonly spoken of as "The North Star of King Solomon," and the other on the north base of Sultan Mountain. The former will be referred to in this report as "The North Star (King Solomon) mine."

has been $1,200,000. The lode on the North Star property is a st
stringer lead, consisting of a zone of country rock traversed irr
larly by ore-bearing stringers. At the croppings, near the summ
Little Giant Peak, this zone is about 100 feet wide. The vein
whole has no walls, and the stringers are usually not accompanie
gouge. The country rock is that found in the Silver Lake Basin,
belongs to the Silverton series. The hard, massive sheets of and
are found to be less favorable for the deposition of ore than the s
breccias. The character of the lode makes it very difficult to w
Ore-bearing stringers may be encountered anywhere within the
of fissured country rock, and frequent crosscutting is a neces
The reduced horizontal projection of the levels, shown in fig. 13,
give some idea of the irregular character of the workings. The

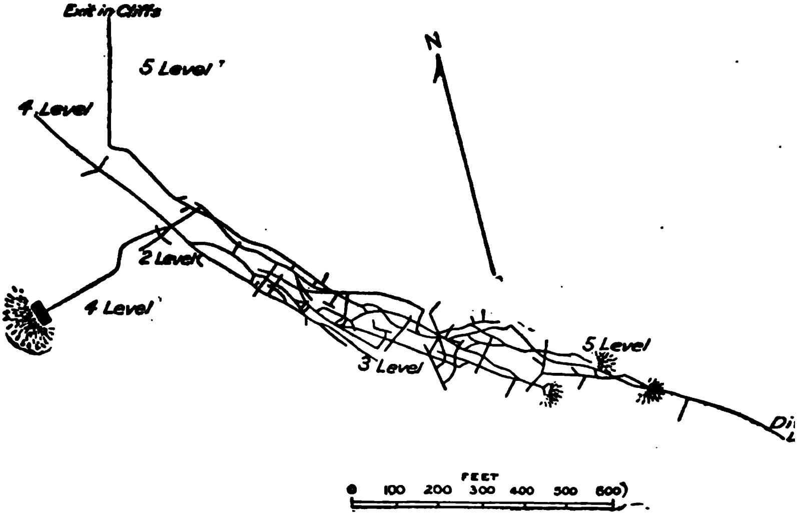

FIG. 13.—Sketch plan of underground workings of the North Star (King Solomon) mi

shoot as a whole pitches to the southeast, apparently at an ang
about 45°. The upper 200 feet, near the surface, was largely sulp
of lead (anglesite) not carrying much silver. This changed in d
to galena, which was associated with increasing amounts of tetr
drite as the ore was followed downward. In the lower levels the ga
was subordinate to the gray copper. This was the most valuable
mineral in the mine, being a highly argentiferous tetrahedrite, o
variety of gray copper known as freibergite. Below the fifth l
the pay shoot failed, although the fissure continues. No serious p
pecting has yet been undertaken to determine whether there ma
be other ore bodies beneath the pay shoot. That there are such
bodies is rendered probable by the fact that ore similar in chara
to that of the North Star mine occurs at a lower level in the D
mine, which adjoins the former on the southeast. The gangue o
North Star ore was quartz. Some gold occurred occasionally in

ore of the lower levels, assays of 6 ounces to the ton having been obtained. This metal, however, formed an exceedingly small proportion of the whole output, which was chiefly in silver.

Owing to the cessation of mining and the accumulation of ice and mud in the abandoned workings, it was impossible to make any satisfactory study of the detailed structure of the lode. Small stringers and gouge seams are said to come in from the foot wall (southwest), as in the Silver Lake lode.

The ore from the North Star was sorted and packed on burros down to the road in Big Giant Gulch. From this point wagons carried it down to the Crooke mill, near the mouth of Boulder Gulch. Built to treat ore from the Polar Star mine, on Engineer Mountain, this mill was originally equipped with a modification of the Augustin leaching process. Its present plant consists of 1 7 by 10 Blake crusher; 10 1,000-pound stamps, dropping 5 inches at 90 to the minute; 5 Harz jigs, 1 Wilfley table, 3 Frue vanners, and 6 canvas tables. Power is furnished by a 60-horsepower engine and boiler. The capacity of the mill is about 50 tons. It is evident that ore so irregularly mined, and milled under such disadvantages, must have been high grade to have paid for extraction and treatment. Much ore that might have been profitably milled in a better-equipped mine has undoubtedly gone on the dump or remained in the stopes.

Dives mine.—This claim joins the North Star (King Solomon) on the southeast and is on the same lode. The workings here are not extensive and the mine has not yet produced much ore. It contains two stopes, one on the Dives and the other on the Shenandoah claim. The general character of the lode resembles that described in the North Star. It is an irregular stringer lead, without gouge and without regular walls. The ore is argentiferous gray copper (perhaps not a normal tetrahedrite, as it carries some lead), galena, chalcopyrite, and pyrite, in a gangue of quartz and barite. Small vugs lined with quartz crystals are common. Much of the vein matter is merely altered country rock, in which the outlines of former porphyritic crystals of feldspar are still recognizable. The ore-bearing stringers are distinctly cut by one, and possibly two, sets of later stringers of quartz, generally parallel to the course of the lode. These later stringers, as far as observed, are small, and are usually barren, though some carry a little ore. Comb structure is particularly common in them. A well-marked spherulitic structure was noted in some of the ore. More or less rounded, irregular lumps of tetrahedrite were surrounded by a skin of chalcopyrite, from which, as a foundation, the quartz had crystallized radially outward (see Pl. XI, C). The high-grade ore may run about 200 ounces of silver. On the Dives claim there is a solid vein of barite, 6 to 7 feet wide, on the hanging wall of the productive lode. Its relation to the latter was not determined. Its presence and the occurrence of barite within the ore body are perhaps connected with the Potomac lode, which is know carry barite, and should join the North Star lode from the nort about this point. Barite was not recognized in the ore of the N Star mine.

The country rock of the Dives is that of the North Star. It s some alteration close to the ore bodies, being bleached in color, ersed by veinlets of quartz, and full of minute cubical crysta pyrite and occasionally specks of galena. The microscope shows it has undergone entire metasomatic recrystallization and con chiefly of quartz, sericite, and pyrite.

The Dives was worked on a lease in 1899, the ore being treat the North Star (Crooke) mill. In 1900 it was idle.

The Mountaineer and Lookout mines have not proved steadily ductive claims, although in the Mint report for 1891 the Looko credited with a production of $27,152. Both are now idle. The nel of the latter is run in Algonkian schists, just beneath their tact with the overlying volcanic rocks of the San Juan series. schists are shattered and decomposed, and the deposit appears t very bunchy and irregular. The ore shows galena, chalcopyrite, pyrite. The Mountaineer is said to have been located by prosp from New Mexico in 1870. At least three veins can be seen crop in the steep bluffs of San Juan breccia above the Lookout tunnel, apparently converging just south of the tunnel mouth in wh locally termed a "blow-out." This is a mass of shattered limes (probably the Ouray limestone (Devonian), which overlies uncon ably the Algonkian schists south of the Highland Mary mine) fragments of schist and andesite, cemented by comminuted and material. Some of the limestone fragments are surrounded by e opes of hematite. The whole mass is somewhat mineralized an traversed by quartz stringers. The origin of this area of local turbance is not certainly known. The original shattering may been due to the movements which formed the veins that converg this point. There has, however, been some recent movement of a l slip character, which has tended to obscure the original relationsh

Big Giant lode and others. In Big Giant Gulch are several l which may be conveniently described in connection with the N Star lode. The most important of these is the one on which Potomac claim is located. Some work has been done on this cl and also on the Big Giant, which appears to be on the same l On the latter claim the lode is apparently a stringer lead, wit any considerable gouge and carrying much chalcopyrite in its It dips southwest at from 75° to 80°. A small mill was erecte this claim, but the mine was not successful, and was idle in Toward the southeast this lode passes over the northern should Big Giant Peak and is supposed to join the North Star vein in Dives claim. There are other lodes in this gulch, two of which on the map, but they have not proved to possess any valu

Little Giant lode.—This lode, which lies between Big Giant and Arrastra gulches, has not been worked for many years, and its chief interest at present is a historical one. Discovered by Miles T. Johnson in 1871, it was the first mine to be opened in the district, and, in contrast with the present mines in the vicinity, produced a gold ore. Such portions of this ore as were not shipped to Pueblo in the crude state were originally treated in arrastras. About 27 tons were treated in this way and yielded $150 per ton. In 1872 the Little Giant Company was formed in Chicago to work the mine, and in the following year the company erected a mill equipped with a Dodge crusher, ball pulverizer, and 5 stamps. Power was supplied by a 12-horsepower engine. The mill was constructed 1,000 feet below the mine opening and the ore was brought down by the pioneer wire-rope tramway of the region. About 100 tons of ore were milled this year, producing about $14,500. The saving is said to have been about 65 per cent of the assay value. The mine became involved in litigation, and this, coupled with the diminution of the pay shoot, led to its abandonment.

The strike of the vein is N. 40° W., and its dip southwest. The pay streak is said to have been about 8 inches wide.

LODES OF CUNNINGHAM GULCH.

General.—Cunningham Gulch, named from one of the pioneers of Baker's company, is the largest of the various side gulches which open on the Animas River above Silverton. At an early date it was the scene of mining activity, and then gave promise of a development which has not yet been fulfilled. In 1899 and 1900 a little work was in progress on the Pride of the West, but otherwise the gulch above its junction with Stony Gulch contained no working mines. Above the Green Mountain mine the bottom of the gulch is excavated in the Algonkian schists, which immediately underlie considerable areas of the volcanic rocks of the quadrangle, but are seldom exposed in its central portion. The San Juan and Silverton formations lie upon the characteristically uneven erosion surface of the older schists. The lodes traverse both the schists and the overlying volcanic rocks, and thus afford opportunity for studying the changes, if any, that take place in the lodes when they pass from the older to the much younger formations. This investigation, however, is unfortunately seriously handicapped by the abandonment of most of the old workings, which has rendered many of them inaccessible. The general course of most of the lodes in Cunningham Gulch is between N. 30° W. and N. 40° W. The Highland Mary vein, however, is about N. 62° W., and still other lodes run more nearly north and south.

Highland Mary mine.—This mine has it workings in the ancient schists at the point where Cunningham Gulch, rising by an abrupt ascent to a higher level, loses its narrow linear character. The schists which compose the country rock vary somewhat in mineralogical composition, but the most common facies is an ordinary hornblende-schist consisting essentially of green hornblende and quartz. The strike of the schistosity is here about N. 48° E. The vein has a strike of N. 62° W., and is practically vertical. Its average width is from 2 to 3 feet, and it is a simple quartz-filled fissure, the vein being adherent, or "frozen," to the schist walls. Several tunnels have been run into the vein, but none of them were accessible in 1899. The only ore minerals seen on the dump were chalcopyrite and pyrite. According to Endlich,[1] of the Hayden Survey, who visited the mine in 1874, the width of the vein is from 4 to 5 feet, and galena and tetrahedrite formed the main ore, accompanied by pyrite, chalcopyrite, and sphalerite. The lower tunnel has a somewhat devious westerly course, and was designed by Edward Innis, its projector, to tap the Royal Tiger and other lodes of the Silver Lake Basin. It was started about 1875 and had reached a length of about 3,000 feet when work was abandoned in 1884. Several veins are said to have been cut in this tunnel, but none were prospected. An inspection of the dump shows that the whole of the tunnel is in schist. The total product of the mine was about $50,000.

Toward the northwest the Highland Mary vein passes upward from the schists into the volcanics of the San Juan and Silverton series. As examined at a point 1,500 feet above the mine buildings, the lode in the volcanics is somewhat larger than in the schists below, having a width of about 12 feet. It is here composed of apparently barren quartz. The lode probably joins the North Star vein on the Shenandoah claim.

Green Mountain mine.—This mine, which is credited with a production of about $100,000, was being opened when visited by the officers of the Hayden Survey in 1874. In 1883 it is said to have produced about 300 tons of ore, averaging 38 ounces of silver and 45 per cent of lead per ton, valued at about $25,000. It was idle in 1899, and evidently had not been worked for several years. The mine was opened through four tunnels, entering on or near the course of the lode. The country rock of the three lower tunnels is a rhyolitic flow-breccia. The upper tunnel is in Algonkian schist. The schist of course underlies the rhyolite, and the fact that it is encountered in the upper instead of the lower workings of the mine is due to the irregularity of the contact between it and the younger volcanic rocks, and to the course of the fissure, which makes an angle with the contact. The strike of the lode is N. 38° W., and the general dip nearly vertical, or at a high angle to the northeast. In the rhyolite the vein is generally about 3 feet wide and is destitute of gouge. It is a simple fissure filling, containing a few small horses of altered country rock. The ore contains abundant sphalerite and galena, with some chalcopyrite and pyrite, in a quartz gangue. In the schists the vein is from 3 to 4 feet wide and fills a clean-cut fissure. The quartz and ore are "frozen" to the cleanly fractured edges of the schists. The latter are slightly impregnated with pyrite, but show less alteration than the rhyolite breccia. The differences in the country rocks have not affected the vein or ore in any way recognizable by the eye. Pay ore was evidently stoped in both. From a scientific point of view it is much to be regretted that this mine is not now in operation and open to inspection.

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[1] Report on the San Juan region: Hayden Survey, 1874, p. 234.

Pride of the West mine.—This was one of the earliest mines in the district to ship out ore. The first lot was taken out by pack animals to Del Norte, on the Rio Grande, and there sold, in 1874. It was from the upper workings, and is said to have contained handsome masses of wire silver. The total product of the mine has probably been near $100,000. In the Mint report for 1884 the mine is credited with a total product from the upper tunnel (level 3) of 1,500 tons, with an average value of $65. This would give a total of $97,500 up to the end of 1884. The product since that time has probably not been large. Work of a desultory character only was in progress in 1899. The general course of the Pride of the West lode is N. 32° W. The general dip appears to be to the southwest at about 80°. Local variations, however, are common. The country rock is a greenish, indurated tuff, belonging to the Silverton series, and probably latitic in character. The upper and older workings are situated some 500 feet above Cunningham Creek, near the croppings of the vein, which are here from 20 to 25 feet wide. A crosscut tunnel of about 80 feet gives access to the lode, which has a threefold character. Next the hanging wall, where cut by the crosscut, lies about 3 feet of apparently fair milling ore, upon which no stoping has been done. This is succeeded on the northeast by 15 feet of quartz, carrying abundant pyrite and chalcopyrite. A division plane, carrying a little gouge, separates these two portions of the lode. Northeast of this wide mass of quartz, and next the foot wall, is the main "pay streak" of the mine. This ore body is a stringer lead. Its thickness, where stoped, was apparently about 15 feet at the most, and usually considerably less. There are no true walls. Stringers from the lode penetrate the foot wall irregularly. For a distance of several feet the latter is traversed by stringers generally parallel to the lode. The lode has been stoped from the main level, and from a level 60 feet below, reached through a winze.

The ore is chiefly galena, occurring in stringers and bunches, with more or less quartz gangue. Pyrite, chalcopyrite, and sphalerite are also present. The richer pockets, however, carried rich tetrahedrite (freibergite), and sometimes wire silver.

A tunnel has been run at a point on the road about 100 feet above Cunningham Creek, for the purpose of cutting the Pride of the West lode at a greater depth and at a more convenient point for working. Many hundred feet of crosscut and drift were run, without, however, finding any pay ore. Much of this rock was on the Silver

Fountain lode, which runs southwest of and approximately parallel with the Pride of the West lode. Its general course is N. 42° W The crosscuts show that between this and the Pride of the West lode, which appears never to have been reached in these lower workings, are several other generally parallel lodes, none of which carry pay ore, as far as prospected.

The ore from the upper workings of the Pride of the West is brought down to the road by a small wire-rope tramway, and is thence hauled to the railroad at Howardsville in wagons.

Philadelphia mine.—This is a small mine higher up the slope and apparently on the same lode as the Pride of the West. Work on it began in 1875, and it is said to have contained a single pocket of ore, chiefly freibergite with a little galena, which afforded about 100,000 ounces of silver. It has been idle for years.

Other lodes.—There are several other lodes on Green Mountain between Stony and Cunningham gulches. Several of these have produced small pockets of ore, but have never been extensively mined. The stronger lodes run approximately northwest and southeast. One of these is prominent along the crest of the mountains. Some large masses of barren-looking white quartz outcrop along the course of the lode, but often the rock (andesite) is bleached and full of small quartz stringers for a width of about 30 feet. About a quarter of a mile northwest of the summit of Green Mountain this lode cuts an older vein of solid white quartz, about 10 feet wide, accompanied by some parallel stringers. This older vein strikes N. 60° E. and dips southeast at 80°–85°. The lode along the ridge at this point dips southwest. On the northern spur of Green Mountain the veins form a complex network. A few only of the better-defined ones are shown on the map. As far as could be determined they are all of the same age. As a rule they show small indications of mineralization. I was informed, however, by the owner of one of the claims that ore occurred in scattered pockets, from one of which he had taken out a carload running 3 ounces of gold per ton.

North of the Pride of the West is a lode running generally parallel to the road. There are several prospects upon it, but it has never produced pay ore. In one of these prospects, the Osceola, just north of the Pride of the West, occurs a very curious banded ore, described more fully in the general section on the ores. Owing to the caved state of the tunnel this banded ore could not be studied in place.

LODES OF GALENA MOUNTAIN AND VICINITY.

General.—Under this heading there will be described not only the fissure deposits on Galena Mountain itself, but those of Maggie, Porcupine, and Stony gulches. Galena Mountain is an exceedingly *precipitous* peak, the upper part of which is composed chiefly of *andesite*, both massive and fragmental (tuff-breccias), belonging to the Silverton series. In its lower portions occur some rhyolite and intrusive masses of monzonite. The mass of the mountain is traversed by very numerous lodes, in great part true veins, many of which are prominent on the surface. Only a few of the more conspicuous ones could be platted on the map, and those with merely approximate accuracy. The number, prominence, and rough parallelism of certain sets of these lodes suggest their division into at least four groups.

(1) N. 45° E. lodes.—Lodes having a nearly northeast and southwest strike are not so numerous on Galena Mountain as they become farther north. The best example in this portion of the quadrangle is the Ridgway lode, the general course of which is about N. 40° E., with local variations. Thus, in the Ridgway mine the strike, as observed in the drifts, is about N. 65° W. The lode dips southeast at from 75° to 80°. The Ridgway lode is faulted by the Alaska lode, with a strike of N. 40° W.

(2) N.-S. lodes.—In this group are included a number of rather short lodes, of which the Veta Madre may be taken as an example. They usually dip to the east at an angle of about 80°. No important ore bodies have been found on any of them, nor was any work on them in progress in 1899. The larger of these N.-S. lodes are often accompanied by parallel fissuring and veining of the country rock.

(3) N. 25° W. lodes.—Lodes of this group are very well seen on the south declivity of the mountain in the vicinity of the Veta Madre mine. The massive andesite is here traversed by a very prominent set of fissures running N. 25° W. and generally nearly vertical. The fissures are closely spaced, a foot or less apart, and are usually occupied by rather small stringers, which are sometimes mineralized. In the Veta Madre tunnel the N.-S. lode is cut by a vein belonging to this group (N. 25° W.), which was followed for about 300 feet, and carried galena with chalcopyrite and probably sphalerite and pyrite. The veins of this group are thus, in part at least, younger than the N.-S. veins of group 2.

(4) N. 65° W. lodes.—Lodes whose courses are within a few degrees of N. 65° W. are generally larger and more prominent than the other lodes of Galena Mountain. Just southwest of the summit of the peak a prominent lode of this group has been extensively prospected. The lode at this point is a large one, striking N. 60° W. and dipping 75° to the northeast. The ore is chiefly chalcopyrite and galena in a quartz gangue. The Neigold mine is also working one of these strong lodes (N. 75° W.), in this case practically vertical. The ore shows galena, chalcopyrite, a finely disseminated sulphobismuthite of lead, specularite, and pyrite, in a quartz gangue. A gray prismatic mineral of brilliant metallic luster, determined as probably bismuthinite, is also present. The veins of this group cut the N. 25° W. veins of group 3, and in one case were observed to cut a vein striking about N. 30° E. They are thus, as far as is known, the youngest veins on the mountain.

Although Galena Mountain has been prospected at many points and has produced some ore, no important ore bodies have yet been developed. The veins in general contain milk-white quartz and some barite and are apparently not heavily mineralized.

Antiperiodic mine.—This is a small property on the east side of Rocky Gulch. The lode has a general strike of about N. 38° W. and dips southwest about 75°. It is irregular and the ore occurs in pockets. The country rock is andesite. The ore consists of galena, with cerussite and wire silver near the surface. Tetrahedrite, chalcopyrite, pyrite, and sphalerite are also present. The total product of this little mine during the twenty years it has been worked amounts to about $12,000. The ore is often of high grade, carrying sometimes 1,100 ounces of silver and 5 ounces of gold, but it is difficult to find and variable in tenor.

Ridgway mine.—This mine is situated on a spur which runs out northeast from Galena Mountain to Maggie Gulch. It was first worked in the summer of 1896 and has paid continuously. The strike of the lode is N. 40° E. and the dip southeast at 75°. The workings consist of two tunnels, with drifts and stope on the upper level. The lower tunnel has just cut the lode, and a winze is being sunk from the upper level to meet it. The country rock of the two main levels is massive andesite. The stope, however, is partly in well-bedded andesitic tuff about 200 feet thick, resting upon an uneven surface of the massive andesite. The tuff is in turn capped by an andesitic flow. The lode in the stope shows a maximum width of 7 feet, nearly all ore. The vein is "frozen" to the walls, the rock of which exhibits considerable alteration. The microscope shows that the andesite near the ore has been changed into an aggregate of quartz and sericite. The gangue of the ore is chiefly quartz, with a little calcite. Vugs are common, usually lined with crystals of quartz, which are sometimes faintly amethystine. Toward the northeast the vein, as followed in the stope, becomes a barren stringer lode. Toward the southwest the ore body is sharply terminated by the Alaska vein, which faults the main lode, apparently offsetting its southwestern continuation to the southeast. No ore has yet been found south of the fault, although the vein continues beyond the offset.

The valuable constituent of the ore consists chiefly of a dark-gray or black, sectile, argentiferous mineral, which contains neither arsenic nor antimony and is, without much doubt, argentite. Curiously, this mineral, with sectility as its most characteristic physical property, is called "brittle silver" by the miners. It occurs finely disseminated through the quartz (Pl. X, *A*) and as small irregular crystals, with quartz, in the vugs. A little ruby silver is reported. There is very little galena in the ore, and the product of the mine is wholly in gold and silver. The ore shipped averages $110 per ton and carries about 3 ounces of gold. Some of it runs much higher. In 1898, 300 tons of ore were shipped, and in 1899 about 150 tons. Ore under $20 in value is thrown on the dump. The crude ore is taken down on pack animals to Middleton and shipped to Durango by rail. It costs $6 per ton to transport it to the smelter. The total product of the mine has been about $60,000.

Gold Nugget claim.—In Maggie Gulch are numerous lodes and veins, nearly all of which have been superficially prospected. The Gold Nugget is one of the oldest of these prospects and has produced about $10,000, chiefly from a single rich pocket near the surface. The value is in gold and silver, and the ore is the so-called "brittle silver," probably in this case argentite. The strike of this vein is N. 10° E. and its dip about 60° to the east. It is a strong, solid, white vein, containing some calcite and barite with the quartz. The country rock is andesite.

Little Maud claim.—This is on a strong vein about 12 feet wide, striking N. 20° E. and dipping southeast about 77°. The vein is frozen to the walls. The country rock is andesite. The ore is similar in character to that of the Ridgway, consisting of the so-called "brittle silver" with pyrite in a quartz gangue. It has thus far been found near the hanging wall, but the pay streak appeared to be changing to the footwall. About 40 sacks of high-grade ore had been taken out in 1899, but none shipped.

As a whole the veins in Maggie Gulch, including the Ridgway, differ markedly in the character of their ores from those hitherto described in Silver Lake Basin, Cunningham Gulch, and on Galena Mountain. They do not contain noticeable quantities of galena, and are mined for gold and silver only. The important ore mineral is the so-called "brittle silver," which usually is finely disseminated through the quartz. As usual, it is not brittle silver (stephanite) at all, but either an argentiferous galena or a mixture of galena and argentite. Common pyrite is also usually an abundant constituent. As far as observed, veins carrying ore of this character all strike east of north. The value of the ore is about equally distributed between gold and silver. The ore is usually of a high grade, but has not been found in large bodies. It is generally in irregular bunches and streaks in prominent, generally barren lodes. Except the Ridgway mine, there are no workings in the gulch which can be regarded as anything more than prospects.

Hamlet mine.—This mine, about three-fourths of a mile south of Middleton, although hardly in Maggie Gulch, may be conveniently referred to in this place. This is a silver-lead-copper mine, which was worked intermittently from 1883 to 1887. Most of the work was done during the last two years, when the mine shipped several hundred tons of chalcopyrite and galena ore. The strike of the vein is N. 50° W. and the dip 80° to 85° to the northeast. The ore is galena, sphalerite, and chalcopyrite in quartz. The country rock is a fine-grained monzonite, and the vein is a simple fissure filling, with little or no gouge. The workings are rather extensive, embracing three adit tunnels, with drifts, stopes, and crosscuts. The ore was taken down to the railroad on pack animals, and it is remarkable that so much work was done on an ore deposit of this character without more effective means of handling and concentrating the ore.

Other lodes.—Just north of Howardsville the precipitous slopes of Dome Peak are traversed by several prominent lodes. There are two sets of these, one with a course of about N. 63° W., and the other about N. 25° E. They are not distinct fissures, such as would result from decisive faulting, but are veins showing considerable regularity for some distance, then branching, anastomosing with other veins or dying out in networks of irregular stringers. There is a tunnel, the name of which was not ascertained, about half a mile north of Howardsville, at the junction of two of the most prominent veins. In it much fruitless work was done, but no extensive ore body was ever discovered and the mine was abandoned. The lodes, so prominent in the cliffs above, seemed to be pinched, barren, and irregular when followed under ground.

LODES OF BURNS GULCH.

General.—Although the lodes in this gulch were prospected at an early date in the history of the region and have produced some ore, none of them have proved permanently productive.

Tom Moore lode.—This lode, reported to have been located in 1870, was being worked in 1881, and then produced a massive galena said to carry about 70 ounces of silver. But its development has been slow and intermittent. Its strike is N. 53° E. and its dip NW. 68°. The country rock is a rhyolitic flow breccia, part of the Silverton series. This, when examined at some distance from the lode, is a light-gray rock showing very conspicuous mottling, due to the brecciation which its material has undergone. Both the fragments and the matrix are essentially of rhyolitic character, although an occasional andesitic particle occurs. The rock is usually streaked and spotted with little nests of epidote. The microscope shows that the original glassy base of the rock has been largely devitrified and is now a fine-grained granular aggregate in which quartz is the only recognizable constituent. Phenocrysts of orthoclase and plagioclase are abundant and are usually partly altered to sericite. Other phenocrysts, presumably ferromagnesian silicates, have been changed to aggregates of quartz and epidote. Areas of chlorite represent what were probably former phenocrysts of biotite. There is also a little calcite present. The accessory constituents noted are allanite and titanite. The lower tunnel, near the Animas River, shows an irregular stringer lead with a well-defined gouge slip along the foot wall. The ore shows chiefly galena, with sphalerite, chalcopyrite, pyrite, and sometimes tetrahedrite, in a quartz gangue. A little rhodochrosite occurs in vugs. The country rock alongside the lode is impregnated with pyrite and specks of galena to a greater extent than is usually observed in this region. When examined in thin section under the microscope, it is seen to be altered to an aggregate of quartz, sericite, and ore, traversed by veinlets of quartz. The original brecciated structure and the outlines of many of the feldspar phenocrysts have been preserved in spite of complete recrystallization. The feldspars have usually been altered to aggregates of sericite.

A second tunnel, several hundred feet above the lowest opening, was not accessible. The dump, however, showed that this portion of the lode was originally a breccia zone in the rhyolite which became filled with ore, accompanied by considerable impregnation and replacement of the country rock. This ore deposit was itself shattered and veined with white quartz, carrying little or no ore.

The upper tunnel, 200 feet above the last, was being worked on a small scale in 1898. The ore streak here is frozen to the walls and carries no quartz save in some small later stringers, often accompanied by kaolin, which cut the ore, and in a few drusy vugs, where it is sometimes accompanied by a little pale-lilac fluorite. The ore is chiefly tetrahedrite, with some chalcopyrite and galena. Sphalerite was not seen. There is said to be some bismuth present, probably as a sulphobismuthite of lead, and the occurrence of hübnerite was noted in small crystals in the later quartz stringers. The width of the lode is usually from 3 to 6 feet, and it is in part a replacement of the rhyolitic walls. The chalcopyrite occurs chiefly in the middle portions of the ore stringers. The tetrahedrite on each side of it is solid for a short distance and then fades off into the altered country rock as minute veinlets and specks associated with chalcopyrite or pyrite. Such gangue as is present with the ore is altered rhyolitic flow breccia, consisting chiefly of finely crystalline quartz and sericite. The lode is thus not sharply differentiated from the country rock on each side of it. The tetrahedrite is not highly argentiferous. The first-class ore runs about $60 to the ton and the second-class about $48. The chief value is in copper, but there is some silver and a little gold, the last sometimes in visible particles. Free copper is not uncommon in these upper workings, but is confined, as far as is known, to the small stringers of younger white quartz which cut the ore. These sometimes show comb structure, and the copper occurs along with the medial suture of the stringers.

The middle tunnel is said to have furnished ore carrying more galena and higher in silver, with subordinate amounts of tetrahedrite, while in the lowest tunnel tetrahedrite was rare.

Silver Wing mine.—This property comprises several lodes, of which one is the northeast extension of the Tom Moore. Some development of these lodes was in progress as early as 1880, but they have never been successfully worked. An extensive tunnel has been run in from the Animas River near the mouth of Burns Gulch, and a costly mill has been erected to treat the ore when it should be found. The property became involved in legal difficulties, and in 1899 all work had ceased before ore had been discovered in paying quantities.

LODES OF SUNNYSIDE BASIN.

General.—Although the Sunnyside mine is the only one in the basin now producing, there are several other large lodes which have in the past produced ore from superficial workings. In the general character of their ores they show much similarity. They are all of prevailingly low grade, although the Sunnyside contains masses of richer ore carrying free gold. The lodes are unusually massive, in some cases over 50 feet wide, and all carry abundant rhodonite. The ore minerals are galena, sphalerite, chalcopyrite, pyrite, and sometimes tetrahedrite and free gold. The ore minerals are usually rather evenly scattered through a quartz gangue, and the ores are more siliceous and the galena is more finely crystalline than in those of the Silver Lake Basin. The large veins at the head of Lake Emma are curved and show abrupt changes in their courses. The cause of these irregularities is not apparent.

Sunnyside mine.—Situated in the basin at the head of Eureka Gulch, this mine enjoys the distinction of having been an almost continuous producer from the first discovery of the region. It is to-day one of the few mines in the quadrangle that are actively working on a considerable scale. The deposit, like many another prominent lode in the district, was located in 1873, while the land was still held by the Indians, and afterwards relocated when the San Juan country was thrown open to settlement in 1874. It was worked as a prospect in 1875, and about four years later produced considerable ore. Thompson Brothers worked the mine for several years, during one of which they are said to have taken out $385,000. The rich gold ore which made the early exploitation profitable finally gave out. A 10-stamp mill was erected at the outlet of the lake and an attempt was made to concentrate the lower-grade ore. The effort resulted in failure. Finally, about 1890, J. H. Terry put up the present mill in Eureka Gulch and operated it successfully. About 1896 this mill was connected with the mine by a wire-rope tramway. In 1899 a second mill was completed at Eureka, designed to relieve the work of the upper mill by concentrating the lower grades of ore which do not require amalgamation. A tramway was also constructed connecting the two mills.

The Sunnyside lode is very large—30 to 50 feet in width. Its general strike is about N. 50° E. and it dips to the southeast at 65° or 70°. Toward the northeast it passes through a saddle, where it is known as the Sunnyside Extension lode, and continues down Placer Gulch.

Southwest of the Sunnyside the lode becomes the Belle Creole, curves sharply westward, and is concealed by alluvium at the head of Lake Emma. A short distance northeast of the Sunnyside lode, and nearly parallel to it, is the No Name lode, dipping 75° to the southeast, and joining the Sunnyside in the Sunnyside Extension ground. Between this lode and the Sunnyside are at least three other veins, making in all a very large body of low-grade ore. The Sunnyside vein is frozen to the walls, and gouge is usually absent. The ore minerals of the vein are galena, sphalerite, chalcopyrite, pyrite, tetrahedrite, and free gold, in a gangue of quartz and rhodonite. The ore streaks occur irregularly in the vein, between partitions of rhodonite. As a rule the ore occurs near the walls, and when an ore shoot pinches on one wall it usually thickens on the other. The best ore, carrying free gold, occurs in irregular lenses parallel with the plane of the lode and sometimes 30 or 40 feet in diameter. It is usually associated with rosin-colored sphalerite and small amounts of lilac fluorite. These are regarded as useful indications, but are not invariably accompanied by free gold. The ore has been brecciated to some extent since its original deposition and is sometimes traversed by a network of veinlets. These are usually filled with quartz carrying a little chalcopyrite. But where the veinlets traverse rhodonite they are often filled with that mineral instead of quartz. The exact relation of the rhodonite "partitions" to the ore is not always clear. In some cases the rhodonite appears to form the mass of the vein, in which the ore occurs as lenticular bodies, and sometimes lenses of rhodonite are surrounded by ore. The large masses of rhodonite, or "pink," as the miners term it, are never regarded as ore, although they are not destitute of the ore minerals. The material is rose-pink in color on fresh fracture, very compact, and exceedingly tough to work. It always contains a little quartz, calcite, and rhodochrosite. The rhodonite sometimes occurs as distinct stringers cutting the quartz and ore, while in other places it may be seen intimately and irregularly intercrystallized with them. As far as observed, neither the rhodonite nor the ore shows any regular megascopic structure, such as banding, crustification, or comb structure, other than the general relationship already indicated.

The No Name lode has not yet been commercially worked. Where seen it showed about 6 feet of quartz and ore on the foot wall and about 4 feet on the hanging wall, the two streaks being separated by 10 feet of rhodonite (fig. 7, p. 88). The ore is chiefly galena.

The Sunnyside is worked through a main adit tunnel about 100 feet above the lake. There are two other important levels above the present adit. Underhand stoping is employed, resulting in empty stopes of great height. Fortunately the nature of the country rock is such that the men working in the bottoms of these stopes are fairly safe from falling material. There are no stopes as yet below the main adit level. As is too often the case in the mines of this region, adequate maps, showing the underground workings and the shapes of the ore bodies as developed up to date, are lacking.

The chief product of the mine is in gold and lead, the silver averaging not much more than 11 ounces per ton. Occasional streaks of tetrahedrite may, however, carry as much as 400 ounces. The ore is carried on a Finlayson wire-rope tramway down to the mill in Eureka Gulch. This mill is equipped with 1 Blake crusher, 15 stamps of 650 to 700 pounds weight, dropping 55 to 60 times a minute, 3 Bartlett tables, 2 Wilfleys, and 2 canvas tables. The power is water. The batteries are provided with one amalgamated copper plate each. The capacity of the mill is 30 to 35 tons daily. In 1900 this mill was not in use, and all the ore was sent down on a Finlayson tramway to the new mill at Eureka, originally designed for a concentrating mill and furnished with rolls. The equipment of this mill is at present one 11 by 15 Blake crusher, 20 stamps, 3 Wilfley tables, and 5 Bartlett tables. Power is supplied by 2 Pelton water wheels.

La Belle Creole.—This claim is on the main Sunnyside lode, which has here turned so as to strike east and west, dipping south 75°. The croppings are very prominent and have been worked by open cuts and through a small tunnel. Several pockets of good ore have been taken out near the surface.

The Lake claim is on a prominent lode just north of Lake Emma. This has also produced some good ore and has been worked by an open cut and small shaft. The strike of the fissure is N. 74° W., and the dip practically vertical. The continuation of this lode toward the east is lost beneath the talus. On the west it appears to be connected with the George Washington lode, although the two are not in line.

The George Washington is a strong lode, striking east and west and dipping south 70°. It also has been superficially worked by an open cut and a shallow shaft. In 1900 a new prospecting shaft had been sunk south of the vein and a crosscut driven across the latter, here over 100 feet wide. About 20 feet of very compact rhodonite was cut through about in the middle of the vein, and alongside the rhodonite, on the north, is about 5 feet of ore, carrying in places as much as 9 ounces of gold. Most of the vein, however, is of low grade. The relation of the rhodonite to the ore is similar to that described in the Sunnyside mine. The George Washington vein shows no gouge and no regular walls. The ore resembles that of the Sunnyside in general mineralogical character, but perhaps carries more galena. The lode apparently curves and passes through the saddle into Ross Basin, down which it is easily followed by its remarkably prominent croppings.

Ben Franklin mine.—This is an enormous lode of low-grade ore, in places over 100 feet in width, which crosses Eureka Gulch about half a mile below Lake Emma. Its strike is N. 43° E., and it dips northwest from 45° to 60°. This mine caused considerable excitement in 1883. Two tunnels, 20 and 80 feet in length, had been run and some 300 tons of ore averaging $36 per ton had been taken from the longer tunnel. An inclined shaft was also sunk for a short distance on the lode. The ore consists of sphalerite, galena, chalcopyrite, and pyrite, in a gangue of quartz and rhodonite. Masses of richer ore, carrying tetrahedrite and native silver, are said to have occurred in caves within the lode. A road was built up Eureka Gulch to the mine, but the latter did not fulfill expectations and was abandoned.

PLACER GULCH AND TREASURE MOUNTAIN GROUP OF LODES.

General.—As may be seen by reference to the map, on which only a few of the most prominent viens are shown, the veins of this areal group form a complex network in which certain dominant directions of fissuring are plainly recognizable. There is a series of strong, continuous lodes, represented by the Sunnyside and Scotia veins, having a general course of about N. 40° E. The dip of these is southeasterly at a high angle. The Scotia lode appears to be a very persistent one. There is good reason to suppose it to be continuous with a lode which passes up Cinnamon Creek and over Wood Mountain to the Lake Fork of the Gunnison. A second system of shorter, less conspicuous veins crosses the first series almost at right angles, with a course approximately N. 55° W. These are nearly vertical, but the majority of them dip southwest at high angles. Whether they are older or younger than the dominant northeast veins could not be satisfactorily determined with the exposures at hand, although some of them appear to cut the Scotia lode. A third system of transverse veins, represented by the Golden Fleece, has a course about N. 75° E., with usually steep southerly dip. Besides the three systems already noted, there is a very prominent set exposed at the head of Placer Gulch, which have an average trend of about N. 25° E. Their dip is usually steep and easterly. They resemble in character the great Sunnyside lode, and in most cases are branches of the latter, forming with it a fan-like group somewhat similar to that previously described in Silver Lake Basin.

There are several other lodes in this area which do not strictly belong with any of the systems noted. Several of them have a nearly east-and-west strike and might perhaps be grouped together, or possibly included with veins of the Golden Fleece system.

The country rock of all these lodes is in the main the Silverton series, with a few masses of intrusive rhyolite.

The Sunnyside Extension lode and those just described as its branches resemble very closely those in the Sunnyside Basin. They are for the most part strong, heavy lodes with bold outcrops, to which the abundant rhodonite, by oxidation, generally gives a black color. Underground it is seen that these lodes are as a rule composed of alternating bands or streaks of ore and barren pink rhodonite. The ore bodies may vary from a few inches up to 30 feet in width. They are sometimes continuous for long distances, but are elsewhere plainly lenticular. The miner has sometimes followed a single ore streak for a considerable distance without suspecting that another ore body lay close alongside, separated from him by a partition of rhodonite. The ore streaks frequently show irregular banding, by deposition, and often contain small vugs. The ore minerals are sphalerite, galena, pyrite, chalcopyrite, free gold, sulphobismuthites of lead and silver, and sometimes small amounts of tetrahedrite, molybdenite, native silver, and native copper. The sphalerite varies from dark brown to rosin-yellow in color, and usually about equals the galena in amount, and exceeds the other ore constituents. The light-colored zinc blende often accompanies ore rich in free gold. The gangue is quartz, rhodonite, and locally a little fluorite and calcite. The rhodonite, which forms the "partitions of pink" between the ore bodies, is tough and compact, and varies from light pink to rose-red in color. It is always poor in ore minerals when it occurs in large masses, but small amounts of rhodonite may be embedded in the richest ore.

In spite of the banding on a large scale shown by the veins, they are as a rule simple, thick plates of vein filling, frozen to the walls and containing very few horses of country rock. Of low grade as a whole, they have hitherto been mined for the richer portions, carrying free gold.

Sunnyside Extension mine.—This property joins the Sunnyside on the northeast, and is on the same lode. The main lode dips southeast about 75°. Just northwest of it is a second lode, nearly parallel and bearing to it a relation similar to that which the No Name bears to the Sunnyside. This second lode also dips southeasterly, but in places it is as flat as 40°. It probably joins the Sunnyside vein in depth.

The Sunnyside Extension mine was first extensively worked in 1886, when $3,965 worth of ore was shipped. It was worked steadily until 1892, producing in all $337,687. After a short intermission it was again worked up to about 1897, but the output for this period is not known. The mine is now (1900) being again reopened. The ore resembles in general character and occurrence that of the Sunnyside mine, but is more irregular in its distribution. There are three main levels, all connecting with the surface by adit tunnels. Above level 2 is a stope about 30 feet wide, 200 feet long and 125 feet high, which is said to have been practically all ore. Some very rich ore has been taken from this mine, carload lots running as high as 74 ounces of gold per ton, together with silver and lead. The gold occurred very largely free, and, as in the Sunnyside, was limited to certain pockets or bunches within the mass of the otherwise low-grade vein. Specimens of this ore in the possession of Mr. Rasmus Hanson, of Eureka, showed the gold scattered through masses of friable spongy quartz, and also as implanted crystals on the quartz crystals of drusy cavities or vugs. It also occurs embedded in a dark-gray mineral locally termed "graphite," but which in reality is molybdenite,[1] in a sulphobismuthite of lead and silver not specifically determined, and also in light-yellow zinc blende. A little native silver sometimes occurs with the gold, and some native copper was in the upper workings. The general mineralogy of the vein is identical with that of the Sunnyside.

The Sunnyside Extension (Hanson's) mill, erected in 1889 near the head of Placer Gulch, is equipped with a Blake crusher, 20 750-pound stamps, dropping 9 inches at 64 to the minute, 4 Gilpin County shaking tables, and 2 Woodbury tables. The mill was driven by steam and has a capacity of 47 tons per day. Ore was brought down to the mill on a Huson tramway 2,300 feet in length, with 61 buckets and a daily capacity of 175 tons.

The Mastodon is on the same lode as the Sunnyside Extension mine, and lies just northeast of the latter. This claim has never been extensively developed. It is known to contain some rich silver ore, but this is irregularly distributed through the large low-grade lode. A mass of this ore, consisting chiefly of an argentiferous sulphobismuthite of lead in a fine aggregate of quartz and barite, was assayed by Mr. Hanson and found to carry 400 ounces of silver. The sulphobismuthite occurs as a bright lead-gray mineral, finely disseminated through the quartz and barite, or in minute ragged prismatic crystals. It is not practicable to obtain the mineral in sufficient purity and quantity to warrant quantitative chemical analysis, by which alone the mineral species could be determined.

The Mastodon mill was one of the earliest to be constructed in the district. In 1899 it had been repaired and was working on ore from the Silver Queen mine. Its present equipment is a Blake crusher, 2 sets of rolls, 1 Huntington, 1 double compartment jig, 2 sets of revolving screens, 1 large Bartlett table, 2 "double-deck" Wilfleys, and 4 slime tables. Its capacity was said to be 35 tons.

Silver Queen.—This is a small mine at the head of Placer Gulch and about one-fourth mile east of the Sunnyside Extension. The lode is somewhat irregular, but appears to strike about N. 10° W. Its dip is to the west and unusually flat for this region, being near 40°. Considerable work has been done, but in a most unsystematic manner. The ore seen showed galena, pyrite, chalcopyrite, tetrahedrite, and sphalerite, in a gangue of quartz and rhodonite, with a little rhodochrosite. It is also said to carry some free gold. This mine has produced some good ore, but how much is not known. The silver is said to have occurred largely in combination with bismuth, probably as a sulphobismuthite of lead and silver. In 1899 a crosscut was being driven to cut the extension of the Sound Democrat lode to the eastward.

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[1] T. A. Rickard has erroneously referred to this as graphite, supposing that it aided in precipitating the ore. See The Enterprise mine, Rico, Colorado: Trans. Am. Inst. Min. Eng., Vol. XXVI, 1897, pp. 976–977.

Hidden Treasure, Pride of the Rockies, etc.—These claims are located on lodes lying radially in the angle between the Silver Queen and the Sunnyside Extension. They have been prospected in a small way and have produced inconsiderable amounts of ore. According to Mr. Rasmus Hanson, ore from the Hidden Treasure vein has assayed 300 ounces of silver and 4 ounces of gold per ton. In their general character these lodes resemble the others of this group already described. The lodes at the head of Placer Gulch are exceedingly numerous, and those named or those indicated on the map comprise merely a few of the more prominent ones.

Sound Democrat.—This also is a small mine which was being developed in 1899. The principal lode strikes N. 20° E. and dips northwest about 68°. The portion of the lode now being worked is very irregular, the ore occurring in bunches, as if the lode had been broken up and the parts displaced. Much of the irregularity is apparently due to the fact that two or more transverse or intersecting lodes occur in the workings. Owing to the absence of maps and the small scale of the present workings, it was impossible to make a satisfactory study of the ore bodies. In its general mineralogical character the lode resembles the Sunnyside. The ore shows pyrite, sphalerite, galena, chalcopyrite, and free gold, in a gangue of quartz and rhodonite, and a little rhodochrosite. A gray metallic mineral occurring in minute particles in some of the ore is probably one of the sulphobismuthites of lead. Gold is the most important constituent, and occurs free in fine particles in the quartz and in the pyrite. Chalcopyrite is not abundant, and when present is regarded as an indication of the presence of gold. The galena in the best ore occurs in such fine particles as to make its recognition difficult. Quartz is the principal gangue mineral, and often shows small vugs. In 1899 the ore of the Sound Democrat was being packed on burros to the upper Sunnyside mill in Eureka Gulch and there treated.

Scotia lode.—This is a very prominent lode, which outcrops along the southeast slope of Treasure Mountain. It is probable that the same fissure or fissure zone crosses the Animas River and extends up Cinnamon Gulch and over the southeast shoulder of Wood Mountain. Its strike on Treasure Mountain is N. 43° E. and its dip about 75° to the southeast. It is occupied by a large low-grade lode, with a more or less black outcrop, owing to the oxidation of the rhodonite of which it is partly composed. Although prospected at many points, it has not been profitably worked. The Scotia claim has produced some high-grade ore, but it has come from a small transverse vein, the olden Fleece.

Golden Fleece vein.—This is a very small and tight vein which has produced some rich free-gold ore. The strike of the vein is N. 75° E. and its dip about 75° to the south. Its width varies from a fraction of an inch to 6 inches, and it is unaccompanied by gouge. Although so small, the vein is remarkably regular and has been extensively stoped. As it approaches the Scotia lode it breaks up into stringers and grows poor. This splitting up of the vein into stringers as it approaches the Scotia lode is at least an indication that the latter is older.[1] Toward the east it bends southward and joins the Golden Fleece extension, a low-grade lode approximately parallel with the Scotia. The ore of the Golden Fleece is free gold, which occurs in beautiful dendritic forms made up of thin branching plates of gold embedded in a gangue of quartz with some pale-pink rhodochrosite. The quartz near the gold is usually dark colored, and this darker shade is apparently due to the presence of extremely minute particles of pyrite, galena, and sphalerite, and possibly other ore minerals. The gold occurs both in the quartz and in the rhodochrosite. Some beautiful specimens of rich gold ore from this little vein were seen in the possession of Mr. Hanson, of Eureka, who worked the vein for years. The product was all sorted and shipped as crude ore. There was no work in progress in 1899 when I visited the mine, but a resumption of mining was reported in 1900.

San Juan Queen.—This is a prospect in Picayune Gulch just southeast of the Scotia and Golden Fleece mines. The lode strikes N. 83° E. and dips south about 80°. Its average width is from 3 to 4 feet. The ore consists of pyrite, galena, sphalerite, and a little free silver, in a gangue of quartz with some rhodonite. Much of the galena is very finely crystalline, giving a dark-gray tint to the quartz. The prospect has been developing for about seven years, and has shipped about 10 tons of ore. The best-grade ore is said to carry about 5½ ounces of gold and 180 ounces of silver.

Toltec lode.—This is a prominent lode on the ridge east of the upper part of Picayune Gulch. Its course, N. 40° E., is nearly parallel with that of the Sunnyside and the Scotia. It dips northwest at from 50° to 60°. It has not been worked on any extensive scale and is low grade. In the Toltec claim the vein is in places about 60 feet wide, of solid quartz carrying finely disseminated pyrite, with a more heavily mineralized streak carrying galena, sphalerite, and chalcopyrite near the hanging wall. An upper tunnel on this claim has afforded some coarsely crystalline galena resembling more the ores of the Silver Lake Basin than those usually found in this vicinity. The Toltec was idle in 1899, and has never emerged from the condition of a prospect. Farther southwest the vein carries abundant tetrahedrite, probably in bunches.

Mountain Queen mine.—Situated at the head of California Gulch, under Hurricane Peak, this mine may be conveniently described with those of Placer Gulch. It is one of the oldest workings in the district, and in 1877 shipped 370 tons of ore to Lake City. This ore was carried by pack animals to Rose's Cabin at $3 per ton, and is said to have contained 30 ounces of silver and 64 per cent of lead. The mine was most active from 1878 to 1880, and during one of these years is reported to have shipped $60,000 worth of ore. It was still shipping ore in 1882. It was worked by an open cut and through a vertical shaft. There are at least two large lodes, and the shaft is sunk at or near their junction. The largest strikes N. 80° E. and dips south 75° to 80°. Its croppings are very prominent and in places over 200 feet wide. It is quite likely the same lode as that on which the Custer claim is located, but is not worked in the Mountain Queen. The lode exploited in this mine appears to strike about N. 42° E. and to dip southeast at nearly 85°. It apparently curves somewhat and passes through a saddle east of Hurricane Peak, but the abundant talus and numerous intersecting veins obscure the course of the main fissure. As seen in one of the old levels, 60 feet below the surface, the vein is wide and adherent to its walls. The galena occurs as rather irregular bunches in the quartz near the footwall. At the present time work is carried on by a few leasers in a shallow shaft south of the old works. The ore as sorted for shipping is nearly solid galena. It is associated in the vein with chalcopyrite, pyrite, sphalerite, and sometimes tetrahedrite, in a quartz gangue. No rhodonite or rhodochrosite was seen. Fluorite was observed with some galena ore in a prospect about 100 feet north of the old workings, but may possibly not be on the same vein. The country rock of the Mountain Queen belongs to the Silverton series.

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[1] See von Cotta: Erzlagerstätten, Freiberg, 1859, p. 115.

Other lodes.—Several other lodes than those mentioned have been worked to a small extent in Placer Gulch and on California Mountain. The Evening Star, on the west side of Placer Gulch, has shipped some ore, consisting of galena and tetrahedrite with pyrite, sphalerite, and chalcopyrite, in a quartz gangue. The Custer is a large lode which crosses California Mountain just north of the northern peak. Its strike is N. 81° E., and it is supposed to dip south. It is possibly the same lode as that upon which the Mountain Queen mine is located in California Gulch. The ore of this prospect resembles the Ridgway ore, save in the presence of rhodonite. It carries chiefly an argentiferous lead sulphobismuthite, wrongly called "brittle silver" by the miners, and pyrite. The workings are of a most superficial character. The Black Diamond prospect is on a strong lode striking N. 56° E. and dipping 80° NW., on the eastern slope of California Mountain. It is crossed by another lode striking N. 81° E. and dipping 80° NW., which passes through the saddle between the two summits of the mountain. The ore in this lode is chiefly a gray copper, carrying *both* antimony and arsenic, with lead and a little silver replacing part e copper.

LODES OF MINERAL POINT.

General.—There is probably no area within the quadrangle where outcrop so numerous and such conspicuous lodes and veins as in that immediately surrounding Mineral Point, at the headwaters of the Animas and Uncompahgre rivers. The general trend of these lodes is roughly northeast and southwest, but they are not all parallel. A radial disposition of the fissures is plainly discernible south of Mineral Point, recalling the similar arrangement at the head of Placer Gulch and in Silver Lake Basin. From the knob south of the deserted town (from which the latter takes its name) the croppings of many of the lodes can be followed with the eye for long distances to the northeast and southwest. Unlike large quartz veins in some other regions, the prominent veins here do not stand up uniformly as topographic ridges, but they are, nevertheless, often easily traceable as long white lines stretching away over the uneven country. The summit of Mineral Point knob is formed by a heavy vein of nearly solid white quartz at least 60 feet wide, which dips about 75° to the southeast. Toward the northeast this vein divides into three. The middle branch is that upon which the San Juan Chief is located, while the Bill Young mine is on the eastern branch. Toward the southwest this vein passes over the eastern spur of Tuttle Mountain. The triangle between Houghton and Tuttle mountains and Mineral Point is occupied by a most complicated network of fissure veins. Only the more prominent ones can be shown on the map, and their representation on a map of this scale and character is necessarily somewhat diagrammatic. Some of them follow curved courses, as is well shown by a large vein which crosses the road just west of Mineral Point town and extends southwest toward Lake Como.

Although so numerous and persistent, the lodes in the vicinity of Mineral Point have been productive of more disappointment than profit. Excluding the Old Lout, which will be described with the Poughkeepsie Gulch mines, there has not been a mine in this vicinity which can be said to have yielded a substantial profit over and above its total cost. The Polar Star, on Engineer Mountain, was formerly extensively worked, and produced some rich silver ore; but the ore shoots apparently had little depth, and the net profit of this mine was probably not large when it was finally compelled to close. In 1899 and 1900 the work in this vicinity was practically limited to prospecting or the extraction of small amounts of ore from shallow workings.

The prevailing country rock of the Mineral Point area is andesite, belonging in the Silverton series. There are also considerable bodies of rhyolite, which are intrusive in the andesite, and some latite.

Red Cloud mine.—This claim was first worked about 1874, and in 1881 is reported to have had about 1,200 feet of drifting and to have taken out some 800 tons of gray copper and galena ore in the progress of development. The present workings consist of three shafts, lower adit tunnel, and an unknown extent of drifts. The mine never proved successful, and has been idle for ten or fifteen years. No examination of the underground workings was possible in 1899.

The Red Cloud lode is a very strong one. It passes through the saddle just east of Tuttle Mountain, where its individuality is somewhat obscured by a multitude of intersecting veins. It appears, however, to continue along the southeast slope of Tuttle Mountain and to form one member of the remarkable plexus of veins about Lake Como. Toward the northeast it passes through the Ben Butler claim and over the dividing ridge between the Animas River and Henson Creek drainage. At the Red Cloud mine the lode is split into several members, of which the three most prominent are indicated on the map. The mine is located on the western or main fissure.

Inspection of the dumps shows that much of the ore originally filled a brecciated zone in rhyolite. The ore contains galena, often disseminated in minute particles through the quartz, sphalerite, chalcopyrite, and pyrite, in a quartz and rhodonite gangue. Some of the pyrite has the radial structure usually taken as indicative of marcasite. (See p. 77; also Pl. XI *C*.) Ruby silver (proustite) is also reported. The crude ore is said to have contained about $40 and the concentrates about $15 per ton. The process of ore deposition was attended by much alteration, impregnation, and possibly some replacement of the country rock. Subsequently the ore was brecciated by renewed movement along the fissure and recemented by quartz carrying small amounts of sphalerite and galena.

Ben Butler mine.—This is a prospect on the same lode as the Red Cloud. The lode dips southeast about 75°. It is less evidently brecciated than in the Red Cloud. The country rock is andesite. The ore shows much sphalerite, with galena, pyrite, and ruby silver (proustite), in a quartz gangue. The different ore minerals are not uniformly distributed through the lode, but are more or less concentrated into zones or bands. The best ore is the very finely crystallized galena and ruby silver in a quartz gangue. This galena, minutely disseminated through the quartz, is called "brittle silver" by the miners, but chemical examination shows that this name is erroneously applied. These two minerals are practically confined to two streaks 4 to 8 inches wide. The lode is a large one, and the walls are not exposed in the workings. The latter are 100 feet in depth and opened through an inclined shaft. The shipping ore is said to run about 40 ounces of silver, 40 per cent of lead, and a little gold, which sometimes amounts to 4 ounces per ton. Work on this property was in progress in a small way in 1899 and 1900, and a tunnel was being run to cut the lode at greater depth.

Uncompahgre Chief claim.—This prospect, about a quarter of a mile southwest of the Ben Butler, on an approximately parallel lode, had a shaft 50 feet deep in 1899. The vein is in two main branches, 25 feet apart, and dips southwesterly at about 75°. The ore near the surface consisted of tetrahedrite, presumably argentiferous, and a little galena, in a quartz gangue. The tetrahedrite is erroneously termed "brittle silver" by the prospectors. Another mineral of bright metallic luster and gray color occurs near the surface. It is usually in small, more or less radially grouped prisms in the quartz and is locally termed "star silver." It proves to be a sulphobismuthite of lead and copper, probably argentiferous. The ore in the bottom of the shaft is pyrite in a quartz gangue. A little chalcopyrite and rhodocrosite in small vugs were also observed.

Bill Young mine.—This mine, just east of the dismantled town of Mineral Point, is on the easternmost of the three lodes which join on the summit of Mineral Point knob. It produced some ore about 1876 and was worked to a considerable extent, but it has been idle for many years and few data concerning it could be secured.

San Juan Chief mine.—This mine is on a very prominent lode striking N. 40° E. and dipping southeast at about 75°. It is crossed by a second lode striking about N. 60° E., also dipping steeply southeast. The present developments consist of a shaft 300 feet deep, sunk at the intersection of the two lodes, and a crosscut and drift at the 300-foot level. The work has been unsystematically done and without accurate surveys or maps. No ore has yet been found in these workings, and it is highly probable that the drifting has all been done on the barren intersecting lode and not on the San Juan Chief lode at all.[1] The latter has produced in all nearly $75,000 from open cuts and shallow shafts. The ore from these is very siliceous and consists of quartz and pyrite with a little tetrahedrite. The British Queen claim, which joins the San Juan Chief on the northeast, has produced some gold ore from an open cut, the gold occurring in finely disseminated pyrite in quartz.

In spite of its small output and the fact that no ore body has yet been systematically developed in depth, this mine has been equipped with substantial buildings and expensive machinery. The present mill is the second one that has been erected and has never worked on pay ore from the San Juan Chief. In 1899 it was supplied with two roasting furnaces, a Blake crusher, rolls, 15 stamps, and lixiviation vats. In 1900 the vats had been removed and 3 Cammett tables and a canvas plant substituted. These were running on ore from the Ben Butler. The power is steam.

Polar Star mine.—This property, situated on Engineer Mountain, has been more thoroughly exploited than any other in the vicinity. The average strike of the lode is about N. 25° E., with a dip of about 75° to the southeast. The croppings on the Polar Star claim show very little solid quartz, and the ore occurs in a breccia zone in a latitic andesite. The mine was worked in the late seventies and early eighties, and was idle in 1899. The workings were then blocked with ice and inaccessible.

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[1] The mine was closed in 1900, but I was informed that the main lode had been found by crosscutting on the 300-foot level. The ore, however, ran only $8 or $10 per ton. It is reported to be 30 feet wide.

From the material on the dump it is evident that the ore, after filling the interstices in the brecciated zone of country rock, was itself shattered by later movement and cemented by white quartz. The lode in the lower workings was apparently not accompanied by much gouge and did not possess regular walls. The ore is said to have consisted chiefly of ruby silver and argentite in the upper workings. It was practically free from lead, although a little galena occurs in the vein and some specimens of galena ore were seen from near the southwest end of the claim, next to the Mammoth. The ruby silver occurred in pockets in the lode. In the lower workings the high-grade silver ore is said to have changed abruptly to an ore consisting chiefly of pyrite in quartz, carrying about 12 ounces of silver per ton, with no gold. A similar change is said to have been experienced in all the mines on Engineer Mountain.

The country rock immediately alongside of and included in the Polar Star lode has been bleached and altered by the ore-bearing solutions and transformed to a mixture of quartz, kaolin, and pyrite. The nature of this alteration is discussed on pages 120–124.

The ore from the Polar Star was hauled in wagons down to the Crooke mill on the Animas, near the mouth of Boulder Gulch, and there treated by the Augustine process. It seems to have been well adapted to this treatment, a saving of about 95 per cent being reported.

Other mines.—The Mammoth, Syracuse Pride, and Annie Wood are all mines on the southern slope of Engineer Mountain upon which considerable work has been expended but which are now idle. The Mammoth is on a branch of the Polar Star lode, which here shows croppings of solid quartz nearly 12 feet in width, dipping southeast at 70°. The lode material as seen on the dump is generally similar to that of the Polar Star. This mine is reported to have yielded about $30,000 in silver and gold. The Mint reports give its total product for 1891 and 1892 as $25,655. According to the reports of the Tenth Census, stephanite (true brittle silver) occurred in the Annie Wood and Mammoth mines, together with freibergite, ruby silver, and sulphide of bismuth. It is quite possible, however, that this is an error, due to the very loose use of the term "brittle silver" by the miners. The Mammoth and Polar Star are often asserted to be on the San Juan Chief lode. As may be seen by reference to the map, where the lodes are plotted as accurately as the scale and topography will allow, this assertion is improbable. They are probably overlapping fissures. The Syracuse Pride shipped ore to Crooke & Co., in Lake City, during 1876, and is credited with a product of $10,000 in 1890, but the mine was never successful. Some ore was found in the upper workings and a shaft sunk to cut the lode at depth, but no ore was found, and there is some doubt whether the ore-bearing vein was ever cut in the lower workings.

The Black Silver, on the crest of Engineer Mountain, east of the summit, was developed by a shaft and several tunnels run in on the north slope of the mountain. The lode strikes N. 38° E., and dips northwest at about 75°. It is 18 inches to 2 feet in width, and in general character closely resembles the Polar Star. Some very rich silver ore was formerly extracted near the surface.

The Mohawk, on the north side of Engineer Mountain, was not visited. It was not working in 1899 and 1900.

The Sunset, on the southwest slope of Engineer Mountain, is a small mine which has shipped a few tons of ore. The lode strikes N. 25° W., and dips southwest at an angle of 75° to 80°. It is 4 to 5 feet wide and consists of gouge, crushed decomposed rock, and bunches of quartz and ore. The country rock is a rather coarsely porphyritic altered andesite, like that of the Polar Star. The ore consists chiefly of tetrahedrite and pyrite in a gangue of quartz, with some kaolin.

The Wewissa is a small mine or prospect on the western spur of Engineer Mountain, and is credited with a production of about $13,000 in 1890. It was shipping a galena and tetrahedrite ore, carrying silver, in 1899, the ore being taken by burros and wagons to Ouray. The lode is irregular and is not extensively worked.

The Early Bird, on the north slope of Houghton Mountain, is on a small and irregular vein striking N. 12° E. and dipping 75° to the east. The ore is tetrahedrite and a little galena in a gangue of quartz, which is in part a replacement of the andesitic country rock. The tetrahedrite carries as much as 300 ounces of silver, and gold up to 7 ounces per ton is occasionally met with in small amounts. The prospect has produced 11 carloads of ore ranging in value from $19 to $100 a ton. East of the Early Bird are two prominent lodes striking about northeast, one of which, the Denver, has produced a little ore.

The London, formerly worked through a shaft near the road, north of Houghton Mountain, is now abandoned. It is reported to have produced some ore carrying 3 ounces of gold per ton.

LODES OF HENSON CREEK.

General.—In the northeast corner of the quadrangle are several old locations, some of which have produced ore in considerable quantity, but at the present time active work is limited to prospecting on a small scale.

Frank Hough mine.—This mine, situated in American Flats, under the northern slope of Engineer Mountain, began work early in 1882 on large and irregular bodies of argentiferous and auriferous copper ore. During 1882 the mine was worked through a shaft 250 feet deep, with drifts at 50, 80, 140, and 200 feet below the surface. The lower drift was run nearly 60 feet in solid ore and 100 tons were extracted in running it. During this year some 60 tons of ore were shipped, carrying from 50 to 60 ounces of silver and 25 to 27 per cent copper. The gold varied from a trace up to about one-fourth ounce per ton. A road was built to the mine and a great production was looked for. When the shaft had reached a depth of 350 feet the mine buildings were destroyed by fire and the mine has since lain idle. In all about 2,000 tons of high-grade copper and silver ore were shipped.[1] From the accounts of Mr. J. S. Hough, who operated the mine, the ore body seems to have been an irregular impregnation or replacement deposit alongside a fissure. The country rock is a fine-grained, soft, tuffaceous sandstone, probably of andesitic origin. Near the ore body it is hardened and impregnated with pyrite. This material, when thrown on the dump, weathers to a soft, crumbling mass, stained with the carbonates of copper. The strike of the fissure is N. 23° E., and the dip, according to Mr. Hough, about 45° to the west.

Judging from specimens collected on the dump, the ore of the Frank Hough consists chiefly of chalcocite, often intimately intergrown with quartz, associated with a little chalcopyrite. There is possibly some tetrahedrite present with the chalcocite.

Palmetto mine.—This mine, about 1 mile northeast of Engineer Mountain, is on the continuation of the Polar Star lode, which here has a strike of N. 23° E. and a dip of 75° to the southeast. It was originally owned by J. S. Hough, who stated that the ore in the old workings, near the surface, resembled that in the Polar Star, and consisted chiefly of argentite and ruby silver. It sometimes ran as high as $500 per ton. Several carloads of this rich ore were shipped about 1878. He subsequently sold the mine, and a vertical three-compartment shaft was sunk east of the vein to a depth of 400 or 500 feet, with the intention of cutting the ore body at a depth of a few hundred feet. The ore from this shaft contained much iron pyrite and was low grade. In 1882 a 15-stamp mill was erected on Henson Creek, a mile below the mine, and the ore treated by chlorination. The mine during this year was working five levels, and produced $14,840. It shortly afterwards closed. In the Mint report for 1891 it is credited with a product of $9,566, which, if true, indicates a temporary resumption of activity in that year. The total output is not known. The mine has been idle several years and the mill is dismantled.

Specimens of the ore and vein matter obtained on the dump resemble some of those from the Polar Star. It has been brecciated at least once and healed with comparatively barren white quartz. Small vugs lined with quartz crystals are common. The country rock is andesite, and is evidently considerably impregnated with pyrite and chalcopyrite near the vein.

Dolly Varden [illegible].—This [illegible], situated in Dolly Varden Gulch, was producing copper and silver ore as early as 1878. The lode, as revealed on the surface, is a sheeted zone in an amygdaloidal andesite. The fissures comprising this zone contain very little quartz, and the only ore seen on the surface consisted of the carbonates of copper disseminated through the amygdaloid. Good ore, consisting of tetrahedrite with some "brittle silver," is said to have been taken from a shaft sunk on the lode. A crosscut tunnel 600 to 700 feet in length was run lower down in the gulch, but did not reach paying ore. The dump of this tunnel shows some chalcopyrite deposited in a breccia zone in the andesite. The average strike of the Dolly Varden lode is nearly north and south, with an easterly dip.

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[1] Oral communication from Mr. [illegible] W. [illegible] surveyor of Lake City.

Other prospects.—On Copper Mountain the John J. Crooke, Big Horn, and other prospects have been worked intermittently for many years and have produced some ore, chiefly argentiferous bornite and chalcocite (stromeyerite), with a little galena and some native silver, in a gangue often containing considerable calcite. The strike of these lodes is usually a little east of north, with steep easterly dips. The country rock is andesite.

Other prospects have been opened in a small way in the gulches and basins south of Henson Creek. These are chiefly galena ores, carrying some silver and a little gold, in andesite country rock.

LODES OF POUGHKEEPSIE GULCH.

General.—There is no reason, other than that of convenience, for separating these veins as a whole from those about Mineral Point, of which they are in many cases the direct continuation. Formerly the scene of busy activity, the gulch, with the exception of two or three prospectors, was deserted when visited in 1899. The first location was the Poughkeepsie claim, staked by R. J. McNutt in 1874. In 1879 mining was actively proceeding in several claims. A road was built from Cement Creek to the head of the gulch, and lixiviation works were erected at Gladstone to treat the ore. Since 1890, however, the only work done has been desultory prospecting on a small scale.

In general the longer fissures have trends varying from N. 30° E. to N. 50° E., with southeasterly dips. But they are sometimes curved and irregular, and near Lake Como occurs the most remarkable group of large, closely spaced lodes to be found in the quadrangle. An observer standing on the north side of the lake may count at least five prominent veins running down the steep slopes to the south and west and passing beneath the deep blue water of the tarn. At the point now occupied by the latter the fissures were deflected sharply eastward, and from the eastern side of the lake four prominent lodes and many smaller ones converge at a point on the ridge separating the head of Poughkeepsie from California Gulch. In addition to these, numerous other lodes come in through the saddle connecting with Ross Basin and converge toward the same point on the ridge. The result is a very interesting complex, which is represented as faithfully as possible on the map. But in addition to the lodes shown, the rocks in this vicinity are traversed by innumerable small veins and fissures which can not be indicated on so small a scale. Those shown are chiefly strong massive veins of white quartz, sometimes including considerable country rock, usually carrying a little rhodonite or rhodochrosite, and not showing much evidence of mineral wealth. They frequently branch and are linked together by smaller fissures.

In the saddle between Lake Como and Ross Basin the remarkably thorough manner in which the rock between the main fissures has been sheeted is beautifully shown. This minor sheeting is generally parallel in strike with the larger lodes. At the particular point where the structure was best shown, these sheeting planes dip westerly at about 60°. As many as 50 of them may frequently be counted within a width of a foot. There has been some infiltration of quartz along these minute planes of fracture, which causes them to stand out as little parallel ribs on weathered surfaces. The appearance in the western part of the saddle is as if a series of finely laminated cherty sediments had been tilted up at a high angle. The local strike of this sheeting is about N. 35° E., but it is sometimes disturbed by later cross fractures. No regularity or rhythm could be detected in the spacing of these minor sheeting planes. The country rock is apparently andesite, but too altered and decomposed for certain identification. It may be rhyolitic.

Faulting was not detected along any of the fissures about Lake Como. Study of them was, however, necessarily confined to the surface.

Old Lout and Forest mines.—These properties, situated a mile and a quarter due west of Mineral Point, being closely connected, will be described together. The Old Lout was located about 1876. Shortly afterwards it sold for $10,000 and became, in the years of its activity, the most important mine in the gulch. It has produced between $300,000 and $400,000 worth of rich silver ore, containing bismuth. According to the Mint reports, about $200,000 of this amount was produced in 1884, in which year the mine was the largest producer in the county. It employed about 30 men, raising some 5 tons of ore per day. In 1886 it was sold to a London company for $200,000, and in 1887 it is credited with a product of $86,654. The new owners ran a tunnel some 1,800 feet in length, from the bottom of the gulch, but never found the rich ore which had rendered the upper workings profitable, and about the year 1890 operations were abandoned. The tunnel house and the machinery were subsequently destroyed by fire.

The upper workings were exploited by means of a shaft of unknown depth, which in 1899 was no longer safely accessible. The lower tunnel, being partly caved and filled with a strongly flowing stream of water, can not now be entered. The ore which came from it indicates a strong and well-mineralized lode carrying galena, sphalerite, chalcopyrite, pyrite, and a little marcasite, rather equally distributed in a gangue of quartz with a little barite. This ore is, presumably, low grade. Fragments on the dump show that a part of the lode consists of brecciated and altered country rock (rhyolite flow-breccia) cemented by quartz. The richest ore of the Old Lout is said to have been bismuthiferous, in which case it is probable that an argentiferous sulphobismuthite of lead occurred in this, as in other lodes in Poughkeepsie Gulch.

The Forest mine was worked through a vertical shaft only a few hundred feet east of the Old Lout shaft. Through this it was possible in 1899 to gain access to an upper level 200 feet below the surface. The Forest lode here strikes N. 70° E. and dips south at about 70°. It consists of stringers of ore, without much quartz, traversing altered country rock. These stringers are irregular, sometimes expanding to 2 or 3 feet of nearly solid ore with included fragments of country rock, and again contracting to narrow veinlets. The ore is adherent to the country rock and the lode is without regular walls.

The ore, as seen in this drift and in the ore house, consists of tetrahedrite, pyrite, galena, sphalerite, and chalcopyrite, in a gangue of quartz and barite. The Forest mine was never a profitable producer.

The exact course of the Old Lout lode could not be determined on the ground, but it is more nearly northeast and southwest than the Forest. The two lodes come together southwest of the shafts, and at this junction occurred the rich bismuthiferous ore which made the Old Lout profitable. The lodes are said to have dipped toward each other, the Forest at a lower angle than the Old Lout. If this is true, the dip observed at the 200-foot level of the Forest is not the general dip of the lode.

The country rock of the Old Lout and Forest is a rhyolite, but so much altered in proximity to the ore bodies as to be scarcely recognizable. A specimen taken 7 feet from the Forest lode on the 200-foot level is completely recrystallized and consists of a finely crystalline aggregate of quartz and sericite impregnated with minute crystals of pyrite and galena. As seen in thin section under the microscope, the sericite (and possibly some kaolin) occurs in irregular areas without definite boundaries, and also scattered through the rock amid the quartz grains.

Maid of the Mist mine.—This mine, which has apparently been idle for many years, lies a few hundred yards northeast of the Old Lout and Forest shafts. The workings comprise an inclined shaft of unknown depth and two tunnels, one, a crosscut, cutting the lode about 150 feet below the surface. The strike of the vein is about N. 25° E., and it dips southeast about 65°. It has been drifted upon and stoped from several levels. In the northeast portion of the workings it is a solid vein of quartz 18 inches to 2 feet in width, containing fragments of altered rhyolitic country rock and ore which is apparently of low grade. Toward the southwest the vein has been disturbed by post-mineral movement and is accompanied by crushed wall rock and soft gouge. The course of the vein would carry it into the Old Lout shaft, and it is probable that both mines are on the same fissure.

Alabama mine.—This mine, situated on the east side of Poughkeepsie Gulch, about half a mile south of the Old Lout tunnel, is commonly supposed to be on the same lode as the Old Lout, the strike of the Alabama lode being N. 35° E. The dip is southeast at 70°, although locally variable. In general character the lode resembles that seen in the accessible portion of the Forest workings, but it is more irregular and shows less ore. It is essentially an irregular stringer lead, passing sometimes into a breccia of country rock cemented by quartz and sometimes dwindling to a few narrow and tight stringers. The country rock is rhyolite flow-breccia. Considerable prospecting has been done by tunnels, drifts, and winzes, but apparently no ore was stoped. The mine has been long idle. On the other side of the gulch some work has been carried on upon the same vein, which here appears to dip about 60° to the southeast and shows similar ore.

The ore of the Alabama consists of galena, chalcopyrite, and pyrite, in a gangue consisting of quartz and barite.

Poughkeepsie mine.—This property is situated half a mile up the gulch from the Alabama and on the same side. It was located in 1874 and has produced in all about $12,000. The strike of the vein is N. 62° E., and it is practically vertical. It is a strong and apparently fairly simple vein, frozen to the walls of rhyolitic flow-breccia. It produced a silver ore carrying bismuth. The pyrite in the vein is also said to have carried good values. The tetrahedrite, on the contrary, was poor ore. Argentite is reported[1] as occurring in the ore as mined in 1875. The mine was worked through two tunnels. It has been idle since 1891 and inspection was confined to the surface.

The ore in the bins showed chalcopyrite, pyrite, and tetrahedrite in a quartz gangue.

Amador mine.—This mine, formerly worked through two tunnels, lies on the west side of the gulch. It was deserted in 1899 and little could be ascertained of its history or product. The lower tunnel was originally run in on a small vein striking N. 30° E., but it soon turns and cuts a vein of which the course is N. 80° W. This vein dips north about 60° and is a solid and fairly regular but not heavily mineralized mass of quartz. The lode has been stoped and a shaft sunk from the drift, evidently some years ago. The upper tunnel, 100 feet above, is run directly on the main lode, which is here nearly vertical, and shows from 3 to 5 feet of solid white quartz in the croppings.

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[1] Raymond: Mineral Resources west of the Rocky Mountains, 1875, pp. 383-386.

The country rock, which is rhyolitic flow-breccia, of rather andesitic aspect, is sheeted and traversed by veinlets parallel to and for a distance of several feet from the large lode. A small mill, equipped with crusher and rolls and run by water power, was formerly operated at the mouth of the upper tunnel.

Saxon mine.—This lode is apparently the same as that first followed in the lower tunnel of the Amador. Its strike is N. 30° E., with a steep southeast dip. The mine was working in 1879, and in 1890 is credited with a production of over $30,000. The workings were not accessible in 1899. The ore on the dump showed galena, sphalerite, tetrahedrite, chalcopyrite, and pyrite, in a quartz gangue.

Alaska mine.—Situated about a third of a mile a little north of west from Lake Como, this mine is best known from the occurrence in it of an argentiferous galenobismuthite named alaskaite by Koenig.[1] The mine was working in 1879, and in 1881, when Professor Koenig collected his specimens, had two adits. The alaskaite occurs with tetrahedrite and chalcopyrite in a gangue of quartz and barite, the latter being abundant in the richer ore. Zinc blende and galena were not seen by Koenig, but they are abundant on the dump and in portions of the lode now accessible. Kaolin also was noted, intimately associated with the ore minerals. In 1887 the Mint reports credit the mine with a production of $35,658, but in 1888 it was not producing. I was informed on reliable authority that about $90,000 had been produced in all, chiefly from one large pocket. The Alaska lode strikes about N. 75° E., with a dip of about 75° to the southeastward. At least three veins intersect at or near the old shaft through which the mine was worked; and another lode, the May Belle, which has been superficially prospected, lies just west of and nearly parallel with the Alaska lode. All these lodes carry some rhodonite and rhodochrosite crystallized with the quartz. The country rock is andesite.

In 1900 the mine was being reopened and it was possible to see something of the old workings, although still partly filled with ice. Like many other lodes in this region, the Alaska is less prominent under ground than the croppings would indicate. It contains much altered country rock traversed by stringers of quartz. It is in the soft altered country rock, near the quartz, that the richest ore, alaskaite, occurs as bunches of varying size. Pieces of this ore may carry as much as 3,000 ounces of silver per ton. The solid vein quartz, on the other hand, is low grade, carrying pyrite, galena, sphalerite, and some tetrahedrite, associated with rhodonite, barite, and rhodochrosite.

No ore was extracted from the main workings in 1900, but good bismuthiferous ore, in small bunches, was being taken out from a lower tunnel on the Acapulco claim, which joins the Alaska claim on the east and is under the same ownership.

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[1] Proc. Am. Philos. Soc., Vol. XIX, pp. 472-477; also Vol. XXII, p. 211.

Bonanza mine.—In 1879 this mine was opened on the north side of Lake Como, through a tunnel 250 feet in length, and is said to have produced an ore carrying gray copper (tetrahedrite) and barite. In 1881 it was reported that 700 tons of tetrahedrite and galena ore had been extracted and piled on the dump, and in 1883 some 700 feet of development work had been accomplished. The lode was also exploited by a small shaft near the edge of Lake Como. No great amount was produced and the property has been idle since 1890. The ore seen on the dump in 1899 showed galena, sphalerite, pyrite, chalcopyrite, and tetrahedrite, in a gangue of quartz, barite, and a little rhodonite. The tetrahedrite appeared to be closely associated with the barite. The ore shipped is reported to have carried from 40 to 45 ounces of silver. There are several other idle prospects about the lake, but they present no features meriting special description. A project was at one time set on foot to drain the lake by a tunnel, in order to secure the rich "float" which it was supposed would be found in its bottom. Fortunately for the projectors and for the lovers of the picturesque, this scheme fell through.

Other mines and prospects.—The Red Rogers claim is on a very prominent lode just southwest of Lake Como and crossed by the trail from the lake to Cement Creek. This property, which was well known in the early eighties, has been idle for some years. It was developed by surface cuts and one or more small tunnels, and probably never produced much paying ore. The course of the lode is N. 43° E., with nearly vertical dip. It is the most westerly of the numerous large lodes that converge from the south toward the lake. It does not appear to reach the latter, however, as it curves strongly eastward just north of the Red Rogers cabin (which is on the croppings), and joins the Seven Thirty lode. The Seven Thirty lode is one of the strongest and most persistent lodes of this region. Its course is about N. 85° E. The dip is approximately vertical. Toward the west the lode passes over the ridge into Grey Copper Gulch.

LODES OF THE UNCOMPAHGRE CANYON.

General.—The Uncomphagre River, below the mouth of Poughkeepsie Gulch, has cut the greater part of its picturesque gorge deep into the Algonkian schists. The San Juan andesitic breccias rest upon the uneven eroded surface of these schists, slates, and quartzites, and tower in lofty cliffs above the river. These cliffs are traversed by fractures and veins, which are particularly conspicuous when they cut the San Juan breccias. The cliff faces of the latter are sometimes directly due to the falling away of great masses of rock along one of these fracture planes. Some of the fractures carry ore, and have been worked with varying success.

Michael Breen mine.—This mine, more familiarly known as the *Micky* Breen, is on a small, nearly east-and-west lode (N. 85° W.)

dipping about 85° to the north. The mine has been quite extensively worked through five tunnels. Most of the pay ore has been extracted from the four upper tunnels. The lower one was a more ambitious venture, opened in connection with a mill in an attempt to work the property on a large scale. Although the lode has produced some good ore, it is doubtful whether it is sufficiently abundant, or accompanied by enough lower-grade ore, to justify an extensive plant. The Mint reports credit the mine with a total product of $105,751 during the years 1890–1892. In 1899 the second and nearly third levels above the mill adit were being worked by Italian leasers at a very small profit. The country rock is the andesitic breccia of the San Juan formation.

The lode filling is usually less than a foot in width and frozen to the walls. It is accompanied, however, by considerable parallel sheeting and veining of the adjacent country rock, and the lode itself contains thin sheet-like horses. The fissures are clean cut, regular, and quartz filled, carrying greater or less amounts of ore. Where stoped in the upper of the two tunnels worked in 1899, the lode consists of numerous small stringers, frozen to the country rock and separated by thin sheets of the latter. It is an excellent example of a deposit filling empty spaces in a sheeted zone of much regularity. The pay streak is usually only a few inches wide and lies on the south wall of the vein. It carries tetrahedrite, galena, sphalerite, pyrite, and chalcopyrite. The tetrahedrite is not rich in silver. Small vugs and comb structure are common, often with crystals of tetrahedrite and rhodochrosite projecting with the quartz into the open spaces. The country rock is impregnated with pyrite and chalcopyrite, but is sharply distinguishable from the vein filling. Fluorite was noted on the dump of the uppermost tunnel.

The Micky Breen lode is crossed by a conspicuous system of approximately parallel fissures striking about N. 20° W. and dipping east about 80° to 85°. These fissures usually carry small quartz veins, often showing comb structure. Two narrow and conspicuous zones of sheeting, accompanied by considerable veining, one striking N. 20° W. and the other N. 7° W., are indicated on the map. These converge toward the north and form the lode of the Silver Link mine, and possibly also the Silver Queen lode, in Bear Canyon, on the northern border of the quadrangle. The relation of these fissures to the east-and-west Micky Breen lode could not be determined.

The Micky Breen mill, on the Uncompahgre River, is equipped with a Blake crusher, 2 sets of rolls, 1 5-foot Huntington mill, trommels, and 7 4-foot Frue vanners. It was run by water power and steam. The mill had been idle some time when visited in 1899.

Happy Jack mine.—This property is situated just west of the Micky Breen, and apparently on the same vein. It at one time shipped a little ore and then erected a mill, but the ore gave out. Mine and mill were abandoned, and in 1899 the workings were not accessible. The mill is equipped with roasting furnace, crusher, two sets of rolls, trommels, three sets of mixing troughs, and vats. The ore was apparently treated by the Augustin or a similar process.

Silver Link mine.—This mine is situated on the east side of the canyon, about a mile north of the Micky Breen lode. Its principal adit is a crosscut tunnel 1,700 feet in length. The course of the lode is about N. 12° W. It is nearly vertical. This tunnel was run in the early eighties. According to the Mint reports, the total product of the mine for the years 1888, 1890, and 1891 was nearly $50,000. The mine had been idle since 1873, but was reopened in 1899.

The tunnel mouth is in Algonkian quartzite and schist, but the crosscut soon passes into the overlying San Juan breccia. The latter lies upon a clean and very uneven erosion surface, showing local variations in relief to the extent of 100 feet or more. Sometimes a breccia of schist and quartzite fragments mingled with andesitic material rests directly upon the Algonkian and grades upward, without break, into the typical andesitic San Juan breccia. There is no trace of movement or mineralization along this contact plane.

The lode is a sheeted zone, 20 feet or more in width. The ore is chiefly bornite and tetrahedrite, carrying silver and chalcopyrite, and occurs as bunches along some one of the fissures. It is found in quartz, which is largely silicified San Juan breccia. It contains from 20 to 30 per cent of copper and sometimes as much as 300 ounces of silver per ton. The best ore is said to occur in solid quartz. There has been considerable post-mineral movement along the lode, resulting in soft gouge, and where the disturbance is pronounced it is regarded as unfavorable for ore. The ore usually occurs near the west (called the foot) wall, but it is far from continuous. The country rock on both sides of the lode is traversed by numerous parallel fissures, along which there has frequently been some late movement, as attested by the presence of wet clay gouges.

An old shaft was sunk on the lode for 60 feet below the tunnel level, but apparently did not reach the bottom of the andesitic breccia. Thus it is impossible to gain from this occurrence any light on the important question of what changes, if any, take place in an ore-bearing lode as it passes from the Tertiary breccia to the Algonkian schist. In 1900 this old shaft was being reopened, and it is possible it may be carried down into the schists.

The country rock in the vicinity of the Silver Link mine is intersected by numerous fissures, with a general trend of a few degrees west of north, and therefore approximately parallel with the Silver Link vein. Many of these fissures can be seen extending southward across the Uncompahgre to Mount Abrams. Their average strike, as seen on the surface, appeared to be about N. 5° W. Their dip is 80° to 85° to the east. At the mine these fissures, which do not, as a rule, carry conspicuous lodes, have cut the San Juan breccia into huge, nearly vertical slabs (Pl. VII), which, becoming undermined at their bases, occasionally fall in chaotic ruins at the base of the cliff. A second and less prominent set of fissures, usually carrying quartz stringers, has a general strike of about N. 60° W. The relative ages of the two sets of fissures could not be determined.

Silver Queen mine.—This is a small mine nearly a mile north of the Silver Link, in the canyon of Bear Creek, and on the northern boundary of the quadrangle. The lode, which is possibly a continuation of the Silver Link, here strikes N. 3° E., and is practically vertical. It is a breccia zone, 10 or 12 feet wide, in San Juan breccia, with a clay gouge on the east wall. The pay streak, from 3 to 6 feet wide, lies next the clay seam on the east wall. It is worked through a tunnel 300 feet in length and a 40-foot shaft with short drifts below the tunnel level.

As far as known, the ore occurs in three distinct bodies or shoots, pitching south. In such shoots there is practically no quartz, the ore, sometimes with a little barite, filling the spaces between the fragments of country rock, which is altered to a soft, putty-like material, locally called "talc," but in reality impure kaolin. The northern ore shoot, nearest the tunnel mouth, consists of low-grade copper ore, chiefly chalcopyrite, with subordinate galena and tetrahedrite. It is separated from the next ore shoot on the south by 12 or 15 feet of solid quartz, carrying too little ore to work. This second ore body was rich in a bismuthiferous silver ore (argentiferous sulphobismuthite of lead), associated with galena, at the tunnel level, but changed into chalcopyrite in stoping upward. The third ore body, also separated from the second by a mass of relatively barren quartz, is almost wholly galena ore. South of this ore body the main lode is cut, but not noticeably faulted, by a younger, nearly east-and-west vein, carrying galena, chalcopyrite, and zinc blende and assaying fairly well in gold. South of this intersecting vein the main lode is poor and grows smaller. It is to be noted that not sufficient work has been done to establish the fact that the three small ore bodies cut in the tunnel are really distinct and characterized throughout by different kinds of ore. The fact that the second one changed into chalcopyrite when followed upward would rather tend to negative this idea of the characteristic individuality of these ore bodies.

Post-mineral movement is indicated by the clay gouge along the east wall of the vein and by similar sheets of gouge within the vein, generally nearly parallel to the walls. Contrary to the experience on the Silver Link, the best ore is said to occur in soft clayey ground.

The mine was working a small force in 1899, the ore being packed to the toll road on burros and thence hauled to Ouray in wagons. In 1900 it was idle. The total output has been between $15,000 and $20,000.

LODES OF CANYON CREEK.

General.—Under the above head it is proposed to describe the lodes of Imogene, Richmond, and Silver basins, Potosi Peak, and other portions of the Canyon Creek drainage included within the bounds of the Silverton quadrangle. The only really important mine at present being worked in this area is the Camp Bird. The Revenue tunnel, it is true, has its entrance at Porter, in the Silverton quadrangle, but the lodes worked through it are within the Telluride quadrangle, and have been described by Purington.[1]

Canyon Creek, from near Ouray to the mouth of Richmond Gulch, is crossed by a system of fractures conspicuously visible in the lofty cliffs of the San Juan breccia, and resembling those already noted on the Uncompahgre River. These fractures appear to have an average strike of about N. 35° W., and dip steeply northeastward. They divide the San Juan formation and the underlying sediments into huge, nearly vertical slabs. As far as observed there is no visible vertical displacement along these fissures. They sometimes carry quartz veins, which have been prospected in a small way.

Camp Bird mine.—The Camp Bird lode crosses the head of Imogene Basin, with a strike of N. 80° W. and a dip of 65° to 85° to the south; the average is probably about 70°. Toward the west the lode has been traced on the surface into Marshall Basin, and identified with great probability with the Pandora lode, in the Telluride quadrangle. Toward the east the lode is less easily followed on the surface.

Considerable work had already been done in Imogene Basin prior to 1880. But no high-grade ore had been found, and the locality had fallen into disrepute. The Una and Gertrude claims, on the Camp Bird lode, had been worked for silver-lead ore, but in 1896 had been abandoned, like the other mines in the basin. The presence of high-grade gold ore was first discovered by Thomas F. Walsh, who for many years had industriously leased and prospected a great number of claims scattered over the entire quadrangle. The rich ore was first struck in the Camp Bird, then an undeveloped claim. It was found by Walsh on the dump of the Una and Gertrude claims, which were purchased by him in 1896 for $10,000. At the same time he secured control of practically all the lodes in the basin, much of the necessary surveying being accomplished in the deep snow of winter. The following year development was actively pushed. The substantial tramway connecting the mine with the mill at the mouth of the gulch, 2 miles in length, was completed in forty-nine days. In 1899 the vein had been opened by a crosscut tunnel and about 4,000 feet of drifting, with stopes extending up to the old workings.

In 1900 this tunnel had already been superseded as the main adit

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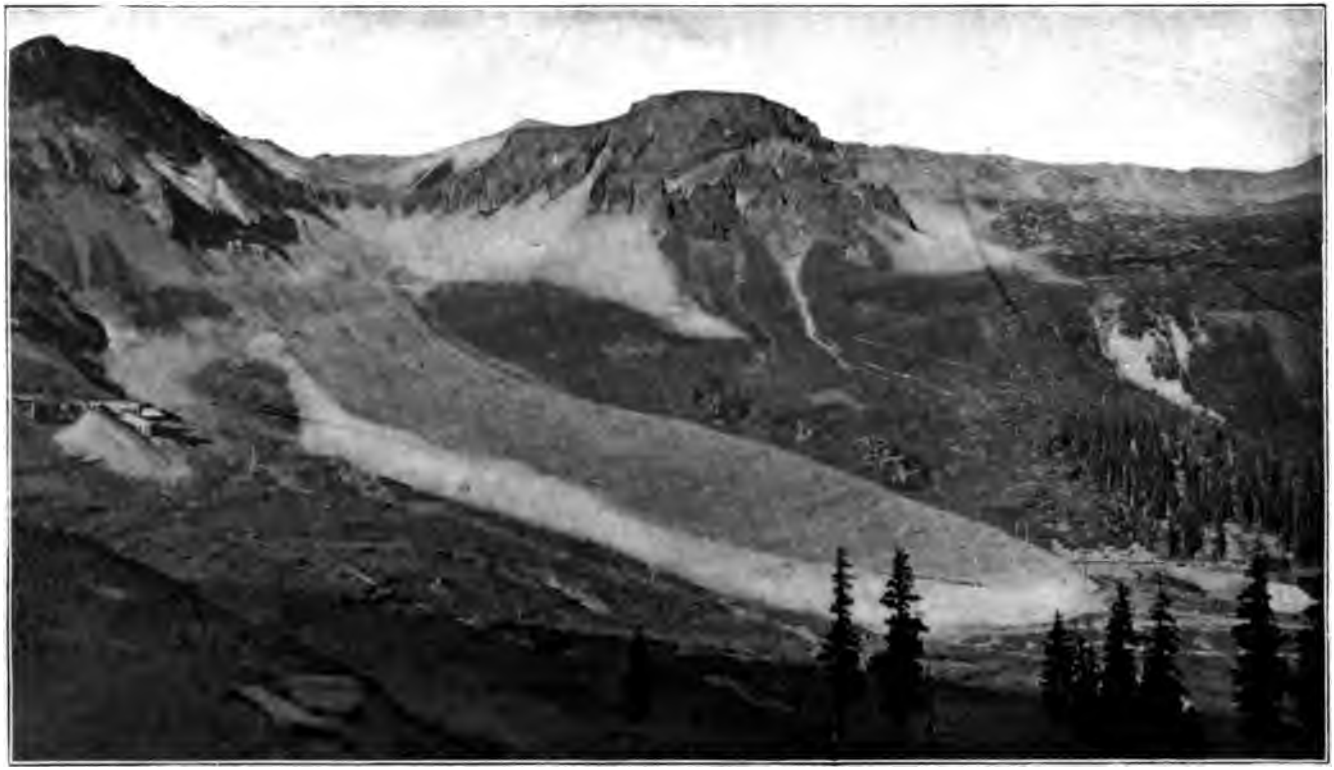
[1] *Preliminary* report on the mining industries of the Telluride quadrangle, Colorado: *Eighteenth Ann.* Rept. U. S. Geol. Survey, Pt. III, 1898, pp. [illegible].



VIEW OF THE SURFACE WORKINGS OF THE CAMP BIRD MINE

The older workings are shown on the left; the present main adit is on the right and runs under the large lobe of talus in the middle of the picture. Photograph by Arthur C. Spencer.

by a much longer tunnel 300 feet below it. This is a crosscut about 2,200 feet in length, driven S. 15° W. It is furnished with a single well-laid track, and in October already connected with over 1,200 feet of drift, which length was being rapidly augmented. A view of the surface features of the Camp Bird mine and of the large lobe of "slide-rock" beneath which the main tunnel is run is shown in Pl. XIV.

The country rock of the Camp Bird is the andesitic breccia of the San Juan formation. As this rock extends to the mouth of the gulch and some way down Canyon Creek, it is probably considerably over 2,000 feet in thickness below the croppings of the lode. It thus insures practical uniformity of volcanic country rock to a rather unusual depth, and is so far favorable to regular and persistent ore bodies.

Nearly all the ore produced under the present ownership has come from the level 300 feet above the new adit. The lode where intersected by this crosscut adit is a mere fracture, the thickness of a knife blade, accompanied by a few small quartz stringers on the footwall side. The fissure soon widens to the east and west, and the lode has an average width of 4 or 5 feet. When typically developed it is a sheeted zone in the rather fine San Juan breccia, made up of narrow stringers of gangue and ore alternating with sheets of country rock, and having fairly well-defined walls. The hanging (south) wall is the more regular, and a very thin seam of clay gouge shows that there has been slight movement along it since the lode was formed. Near the foot wall there is uniformly a streak of lead-silver ore, carrying galena and sphalerite. This is sometimes contiguous with and apparently an integral part of the main lode. At other times the two are separated by a thin sheet of country rock. The vein is unusually adherent to a somewhat irregular foot wall, which is often traversed by irregular quartz stringers, or may be brecciated and cemented by quartz. Although the lode is a sheeted zone, the country rock, outside the recognized limits of the deposit, is not notably fissured. The foot-wall streak of galena ore has been partly brecciated and recemented by stringers of white quartz. This later quartz is not to be distinguished from the quartz of the auriferous portion of the lode and may be of the same period of deposition. The silver-lead foot-wall streak was the ore mined twenty years ago, before the high-grade ore lying alongside it was discovered. The richest ore occurs near the hanging wall, often directly against it, and the richest portion of the pay streak is indicated by dark, narrow, undulating lines of ore minerals. These lines define the course of small stringers, usually an inch or less in diameter, which are of later origin than the mass of the vein. The latter is a pale greenish-white mottled aggregate of quartz, fluorite, sericite, and calcite, thickly sprinkled with small crystals of pyrite, with some sphalerite, galena, and possibly other ore minerals in minute specks. It is probably in part altered country rock. The rich stringers, although very irregular in detail, are remarkably persistent along the hanging-wall side of the main lode. They possess, moreover, a regular internal structure. Next their walls there is usually a thin layer of fluorite. Then follows a narrow band, from one-sixteenth to one-eighth of an inch in width, of rosin-yellow sphalerite and galena, with a few minute specks of chalcopyrite. The medial portion of the stringer is occupied by white quartz carrying a little sericite and calcite. The gold occurs chiefly free in this white quartz, especially close to the dark ore lines near the walls of the stringer. It is firmly embedded in the quartz and is often distinctly visible, although not occurring in large masses.

When the ore is crushed and panned, the concentrates contain abundant free gold in irregular hackly particles, averaging about 0.25 mm. in diameter. Microscopic examination shows that the vast majority of these gold particles have the characteristics of original gold that has been embedded in vein quartz. A very few small, rod-like particles suggest a possible derivation from a telluride of gold. Chemical tests reveal the presence of a very small amount of some telluride in the ore, but it has not been detected by the eye and is not present in sufficient amount to determine its mineral species. Microscopic and chemical investigation shows that the value of the ore is chiefly in free gold and not in telluride of gold.

The quartz in portions of the Camp Bird lode is often very glassy in appearance and shows little trace of mineralization, even when carrying some $20 per ton. Ore below $8 or $10 is not removed. The average value of all the material removed from drifts and stopes on the lode is probably not far from $40 per ton. The average on good stopes, however, may be three or four times this. According to a statement by Mr. J. W. Benson, manager of the Camp Bird mines, the material removed in merely running the main drift, waste included, ran in places about $1,600 per linear foot. Much of the vein quartz on the upper level (300 feet above main adit) is shattered and stained with black oxide of manganese. The shattering of the brittle quartz does not appear, however, to be associated with any very pronounced post-mineral movement, nor has it any known effect on the tenor of the ore. A little rhodochrosite and considerable calcite occur in the lode, the latter often filling vugs or comb structure in the quartz. A soft, white, putty-like substance, which proves to be chiefly kaolin, is also common in the quartzose portions of the lode.

Not enough development has yet been reached to determine the shape of the pay shoots. The ore body on the west drift of the main level is about 1,200 feet in length. Other pay shoots occur along the vein, separated by pinches. They are said to be increasing in length as they are followed down. The ore bodies east of the crosscut are generally wider, but of lower grade than the large one west of it.

About 1,700 feet west of the crosscut tunnel on the main level the lode suddenly contracts and splits into a few small stringers. Beyond this point the country rock on the south side of the drift is lighter colored than elsewhere and is full of irregular quartz stringers, some of which appear to strike southerly into the hanging wall. I was unable in the field to discover any contact or fault in the exposures in the drift, but microscopic study shows that the country rock at this point is a devitrified and altered rhyolite. It is probably an intrusive mass or dike cutting the San Juan breccia. It is exposed in the south wall of the drift for 15 or 20 feet, but has never been found on the north side. West of this contraction no ore was found on this level for nearly 900 feet. A barren stringer was followed for a portion of this distance, which finally led into the main lode, which was found to be offset into the hanging wall. The rhyolitic dike is older than the Camp Bird lode, but its presence has probably caused a local deflection of the generally straight simple fissure. The newly found portion of the lode has been drifted on for 600 feet, and is being followed back toward the rhyolite and point of original deflection. This irregularity is apparently not due to faulting, but is an example of linked-vein structure. The western deflected portion of the lode has an average width of 9 or 10 feet of good ore. The dip is slightly flatter than in the eastern portion of the workings. In the present bottom level of the Camp Bird the galena ore, commonly found on the foot wall above, is less abundant and more bunchy. The dark, curving lines described in connection with the rich ore are less regular and continuous.

Power drills are used almost exclusively for drifting, crosscutting, and stoping. The air compressors are run by electricity from Ames, in the Telluride quadrangle. The ore from the present main level is carried on a temporary Huson wire-rope tram to the tram house near the mouth of the new adit. Thence it goes over the permanent Bleichert tramway to the mill, situated at the mouth of the gulch, on Canyon Creek. This tramway is about 2 miles in length and has a transfer station at the turn in the gulch, in Richmond Basin. In 1899 about 45 buckets were running over it, carrying about 700 pounds of ore each. One man can dispatch 350 bucket loads in a day, of which the mill, then running 30 stamps, required from 325 to 330. All ore goes direct to the mill without sorting. The mill, as equipped in 1899, contained 2 Blake crushers, 40 800-pound stamps, dropping 90 to the minute, and 20 Frue vanners. In 1900 20 more stamps were being added. The pulp from the batteries passes through a 40-mesh screen over silvered copper plates 17 feet long. Thence it passes through classifiers onto the vanners. The latter are so arranged that all the slimes must pass over two vanners before escaping as tailings. The ore passing through the mill is often worth $200 per ton. The average, when visited in 1899, was said to be nearly $150. About 75 to 80 per cent of the total gold is amalgamated on the plates.

The concentrates rarely exceed $4 or $5 per ton of ore. The tailings from the main mill average from $3 to $5 per ton. They were formerly treated in a small auxiliary mill fitted with Wilfley tables. A cyanide plant was, however, nearly completed in 1900, and will treat the slimes directly from the mill. Power for the main mill is supplied by a Pelton water wheel or a 75-horsepower engine. The full capacity with 40 stamps is about 130 tons.

Hidden Treasure mine.—This mine, just north of the Camp Bird, was opened in 1875, but, like other properties in Imogene Basin, has lain idle for many years. It is now owned by Mr. Walsh, and will probably be again worked. It has at present about 2,000 feet of drift, and has produced some ore from its stopes. It is opened by a crosscut tunnel about 150 feet in length. The lode strikes about N. 50° W. and dips northeast at approximately 60°. It is a regular lode, in part occupying a sheeted zone and in part a solid vein of quartz and ore. The country rock is San Juan breccia. There has been some later movement along the plane of the vein, as shown by thin clay gouges. The ore formerly extracted is said to have consisted chiefly of galena and tetrahedrite, and to have contained 100 ounces of silver and 42 per cent of lead. The present workings show a low-grade milling ore consisting of galena, abundant sphalerite, and some chalcopyrite and pyrite.

Hancock mine.—This property lies just east of the present Camp Bird workings, and is also owned by Walsh. The lode strikes N. 55° W., and is very similar in general character to the Hidden Treasure. It joins the Camp Bird lode on the southeast. It has been idle many years, and is not now worked. In 1884 it was said to have furnished in all about 80 tons of ore, but has never been a large producer.

Yellow Rose mine.—This is another old prospect, situated in Richmond Basin, upon which considerable work has been done. In 1881 a "strike" of ore, consisting chiefly of galena, with chalcopyrite, pyrite, tetrahedrite and sphalerite, argentite, and some native silver, was reported on level 2, 470 feet from the entrance to the tunnel. But the mine has never produced much. The vein strikes N. 47° W. and dips NE. 65°. The ore, as seen in 1899, is low grade and very similar in general mineralogical character to that of the Hidden Treasure.

U. S. Depository mine.—This mine, with the Caribou, Grand Trunk, and other claims, is regarded as being probably on the same vein as the Yellow Rose. Considerable work was done on this mine years ago, and in 1887 it was credited with an output of nearly $18,000, but it never was thoroughly successful and has been idle several years. A tunnel some 700 feet in length was run in from the small mill, now dismantled, on the road up Richmond Basin. The vein, as opened at this level, is in part a fairly regular sheeted zone in San Juan breccia and in part a less regular stringer lead. Such ore as the mine produced came from upper workings, 400 or 500 feet higher up the slope, and was carried down to the mill on a light and primitive wire-rope tramway. The ore is a low-grade galena-sphalerite ore, resembling in general character that of the Yellow Rose. Some freibergite has also been reported.[1]

Wheel of Fortune mine.—This lode occupies a strong and persistent fissure, with nearly northeast-and-southwest strike, crossing Canyon Creek just east of the Revenue tunnel. It thus crosses such lodes as the Yellow Rose and Hidden Treasure nearly at right angles, and is the most prominent member of several approximately parallel lodes which may be seen traversing the southern slope of Potosi Peak.

The Wheel of Fortune was located about 1877, and has produced some very rich ore. According to Mr. Krisher, now foreman of the Revenue Tunnel, the mine, prior to 1880, shipped some ore to Black Hawk containing 20 ounces of gold and 800 ounces of silver. In 1879 the mine had about 500 feet of drift and shaft, and was said to have produced $20,000. Most of the work was done in the early eighties. During the latter six months of 1882 the mine shipped about 62 tons of ore, averaging 176 ounces of silver and $8 in gold per ton.[2] The ore appears to have been irregular or pockety in its occurrence, and is said to have contained freibergite and stephanite,[1] with galena and ruby silver. In 1899 the mine was being reopened after several years of idleness.

The local strike of the Wheel of Fortune lode is N. 30° E., and the dip 65° to the northwest. The country rock is San Juan breccia. The lode is chiefly a stringer lead, but it grades on the one hand into a breccia zone and on the other into a fairly regular sheeted zone. It has been faulted along a nearly vertical transverse fissure, the southern portion of the lode being thrown about 15 feet to the west. There has also been movement along the foot wall, as shown by clay seams or gouges. The croppings of the lode extend strongly up into Silver Basin, and the country rock for a distance of 100 feet or more southeast of the lode shows pronounced sheeting unaccompanied by perceptible faulting. There was no opportunity in 1899 for studying the ore in place. In 1900 the mine was reported to be shipping ore, but was not visited.

Bimetallist mine.—This property, situated on Potosi Peak, and probably on the same lode as the Wheel of Fortune, has produced from $40,000 to $50,000 from a single rich pocket near the surface. The ore of this pocket ran usually about 10 ounces of silver and 1 ounce of gold. Chemical examination of a specimen of this ore shows it to be a silver-copper sulphantimonic arsenite (tetrahedrite?), in which the gold is probably combined with the silver. Small portions, however, were very much richer. The workings were idle in 1899 and were not visited.

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[1] Tenth Census, Vol. XIII, 1885, p. 84.

[2] Report of the Director of the Mint, 1882.

LODES OF SAVAGE BASIN.

General.—The upper portion of Savage Basin, although within the Silverton quadrangle, was included by Purington[1] in his study of the lodes of the Telluride area. In 1899 two mines, the Tomboy and Japan, were working in the upper basin, while in 1900 some work was also in progress on the Argentina and the Columbia. The basin contains several large lodes and many smaller ones, all possessing a common northwesterly strike.

Tomboy mine.—The character of the Tomboy lode was so well described by Purington[2] in his report, written in 1897, that his account will be quoted almost entire, and supplemented by the observations made in 1899 and 1900. He says:

> It is only within the past four years that the property known as the Tomboy has made any considerable product; especially in the last two years the output of the mine has surprisingly increased. The workings now on the vein comprise the length of two claims, very nearly, namely, the Belmont and the Tomboy, and several more claims have been located on the vein in its southern extension. The history of this mine is somewhat remarkable, considering its present large output. The original location on the vein was the Belmont claim, made in 1880; and in 1886 the Tomboy claim, to the south of the Belmont, was located. Since the original discovery of the lode, and up to the year 1892, no considerable product was obtained; in fact, the vein was generally regarded as of little value and interests in the claim were sold and resold at very low figures. The Tomboy Gold Mining Company, which bought the mine in 1894, had it profitably working by April, 1895. In that year the product was nearly $600,000, and in 1896 the product was nearly $800,000. Recently the mine has again changed hands, and it is stated that the present monthly output averages about $90,000.
>
> The main adit is at 12,130 feet elevation, very near the head of Savage Basin. The greater portion of the work has been done on one level, consisting of a drift over 3,000 feet in length, with stopes extending up to a height of 200 feet above the drift. As indicated on the map, a second adit, 381 feet vertically below the upper one, is being run to cut the vein. At the time of my visit this was 1,128 feet in length. Its starting point is directly above the site of the Tomboy mill. All the portions of the vein worked during 1896 were in the upper augite-andesite, although the contact of this with the top of the San Juan breccias lies not far below. The lower adit is certainly in the breccias, but the exact level at which the contact occurs it is impossible at present to state. A specimen collected in a winze sunk 100 feet from the main level, although it contains fragments, is of the normal color characteristic of the augite-andesite, and is altogether so decomposed that its microscopic determination is impossible. It was stated that a dike accompanies the Tomboy vein for a part of its length, as now developed. Although I can not say that the observations in the mine confirmed this statement, nor that the microscopic examination revealed any rock differing from that of the country in general, yet in view of the limited examination which was made, it can not be denied that a dike may exist.[3]
>
> The peculiarities of the Tomboy vein, considered with reference to the fissure systems which it follows, have been described and illustrated.[4] So constantly does the vein shift from one to another set of fissures that it is impossible to get,

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[1] Preliminary report on the mining industries of the Telluride quadrangle, Colorado: Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. III. 1898.

[2] Op. cit., pp. 838-841.

[3] No dike was seen in my own examination. F. L. R.

[4] Purington, op. cit., p. 778.

at any one point in the workings, a compass reading which represents its average course. This is, however, as may be measured from the surveys plotted on the map, N. 41° W., while the dip averages 77° to the southwest. The limits of the narrowly cleaved zones, which have been filled by ore, are fairly well defined, and it is only occasionally that stringers accompany the main lode, separated by any considerable amount of wall rock. Such stringers have been found, however, at as great a distance as 10 feet from the main vein. The width of the main lode is variable, but is generally from 4 to 7 feet. It sometimes attains the width of 12 feet, and in one place pinches to less than 1 foot. This vein presents more the character of a solid filling between two walls than most of those seen in the district. The linked-vein type is very well shown in some places, but is subordinate. Angular fragments of the country rock are frequent, and are especially well shown in the faces of the stopes and drifts on account of the whiteness of the surrounding quartz. Figure 73 shows such a fragment included in the quartz. As before stated, the angular character of these fragments is one of the strongest pieces of evidence that the ore is the filling of open spaces, unaccompanied by molecular replacement of the country rock.

The vein minerals are remarkably few in number, and, with the exception of the quartz, do not appear to bear much relation to the values, which are almost entirely in gold. The quartz is by far the largest constituent, is white, and may be described as coarsely saccharoidal, with the spheroidal arrangement of crystals noted above. It is remarkable that much of the quartz which is commonly referred to as "bony," and is ordinarily barren of values, is, in the Tomboy vein, rich in gold, and often contains free gold visible to the unaided eye. Accompanying the quartz there is much blackish, soft material, which has been determined as peroxide of manganese. Although no manganese carbonate has been found in this vein, its general occurrence in neighboring veins makes it probable that it was formerly present, and the oxide is in part the result of its decomposition. The vein, on the whole, presents an unusually decomposed appearance, as does the wall rock in contact with it. Much white, clay-like material, usually of a sticky consistency, from its saturation with water, is of universal occurrence in the vein. This is, indeed, present in such quantities as to give considerable difficulty in the milling of the ore. It is usually known as "talc." Doubtless much of it is merely material residual from the trituration of the country rock along the fissured zones. Some is, however, of more definite composition, and chemical tests prove it to consist largely of finely divided sericite—one of the potash micas. Kaolinite has been shown to occur with it, its presence being probably due to surface decomposition of portions of the wall rock included in the lode. The greater or less amount of this material in the vein does not appear to bear any relation to the value of the ore.

Calcite, and probably siderite, occur. The occurrence of fluorite has already been described at some length. Iron pyrite is present in small amount, and the gold values do not appear to be associated with it to any extent. More often than otherwise it occurs associated with galena and zinc blende in a narrow streak, which crosses from one wall to the other in the vein, and is fairly continuous through the workings. Small quantities of sulphurets are, however, disseminated throughout the vein. The gold is more than three-fourths free, its total value being about $20 to the ton. The concentrates run $40 to $45. The gold averages 0.735 fine. The gold has not been found in the iron pyrite except in small amount. Much of it is extremely finely divided, and hitherto difficulty has been experienced in saving it at all.

Since Purington's observations were made, the lower tunnel has been extended through the main lode to what is known as the "North vein," or Iron vein, some 300 feet beyond. The main lode was cut through and considerable drifting done on the low-grade North lode before the fact was suspected that the main lode had been overshot. These two veins show a very interesting relationship, which will be further described later on. This main adit connects, through stopes and raises, with the drifts of the "300 level," 140 feet below the "200 level." A shaft has also been sunk for 300 feet below the 600 level (main adit level), and drifts run in both directions on the main lode at the 700 and 800 levels, while drifting was about to begin also on the 900 level in 1900.

Purington states that the "vein presents more the character of a solid filling between two walls than most of those seen in the district." To one coming to the study of this lode from the Silverton region, to the east and southeast, its striking feature is the regular and narrowly spaced zone of sheeting and the fact that the lode is composed of a series of more or less regular plates of quartz separated by sheets of country rock. In fact, this structure, combined with that characteristic of the linked-vein type, are the two most prominent structural features of the Tomboy lode. The peculiar intersections, at small angles, of various fissured zones referred to by Purington[1] appears to be a relatively subordinate feature, and was recognized by me at only one place. There is one curve in the main vein which is found on all the levels. At this curve on the 600 level a few small stringers were noted running out into the walls. However, in any but ideal exposures it is manifestly a most difficult matter to distinguish the intersections described by Purington from what I have preferred to regard as an example of linked-vein structure.

The dip of the lode varies from 50° to 80° to the southwest—usually about 70°. It is commonly accompanied by a wet seam of clay gouge along the hanging wall. Along the foot wall is a stringer, or vein, somewhat more solid than the auriferous portion of the lode, carrying galena and zinc blende and "frozen" to the wall. This foot-wall streak is sometimes in contact with the higher-grade gold-bearing quartz, sometimes separated by a plate of country rock. Its solidity and fresh appearance is often in great contrast to the rusty auriferous ore alongside. It has been brecciated in places, and the ore solidly healed with white quartz. The foot wall alongside it has been rather irregularly fractured and veined. I was unable to ascertain whether this foot-wall streak was distinctly different in age from the auriferous portion of the lode.

The crushed and decomposed aspect of the gold-bearing part of the lode, often accompanied by black oxide of manganese, kaolinite, sericite, and copper stains, has been referred to by Purington. That these portions of it have been subjected to some movement subsequent to the original deposition of the quartz is shown by the presence of clay seams traversing the ore. Subsequent fractures filled with wet clay gouge and crushed quartz frequently enter the lode obliquely from the southwest. Some of the richest bunches of ore said to have been found were where they intersect the main lode. The best ore usually occurs in the steeper portions of the vein. The pay shoots are stated to lie flat, one above another, and to extend diagonally across the lode from northwest to southeast.

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[1] Op. cit., p. 778, fig. 66.

The richest ore is invariably found in the shattered and stained parts of the lode, generally alongside a soft gouge of crushed and decomposed andesite. The gold usually occurs free and very finely disseminated. When visible, it is embedded solidly in the unpromising-looking vitreous quartz, although Mr. Roscoe Wheeler, the assayer at the mine, informed me that he had found one piece of gold in a fracture plane in the quartz. In the more recent workings, below the 300 level, the vein is, as a whole, less shattered and stained. Even at the 800 level, however, portions of the lode exhibit the character above described, accompanied by clay seams, and such portions are always rich. On this level the vein is sometimes 10 to 12 feet wide, with 2 to 3 feet of galena ore on the foot wall, the latter ore being more abundant here than in the upper levels.

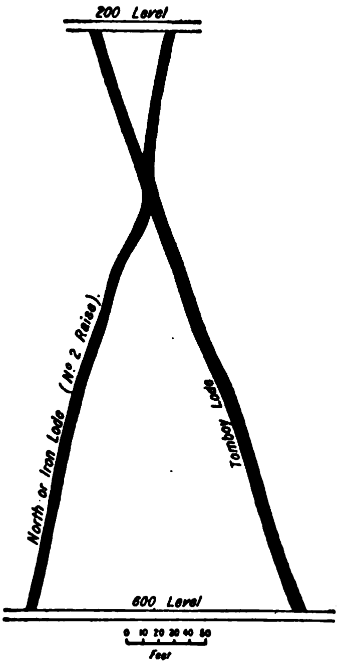

FIG. 14.—Cross section of the Tomboy and Iron lodes through No. 2 raise, between the 600-foot and 200-foot levels. Platted from notes of surveys by Mr. John Herron.

The description thus far has been of the main Tomboy lode. There remain to be described the Iron lode and its relation to the Tomboy. The two lodes are nearly parallel in strike, the Iron vein having a slightly more westerly course than the Tomboy, which is about N. 40° W. But the Tomboy lode dips to the southwest, whereas the Iron vein dips northeast. As a consequence of this diversity of dip the two veins intersect, so that the Iron vein, which above the 300 level was encountered on the northwest side of the Tomboy, on the lower levels is found on the northeast side. Near the main adit this intersection takes place at about the 300-foot level, but the line is not horizontal. The slight difference in strike of the two lodes gives their intersection a pitch to the northwest of about 6° from the horizontal. The intersection in vertical plane is shown in the accompanying cross sections (figs. 14 and 15), drawn from notes of surveys made by Mr. John Herron. The relation of these lodes is such that at each level, if carried far enough, there should be found a place where the two lodes cross in a horizontal plane. The confluent portions, however, must lie much farther northwest, theoretically about 950 feet for each additional 100 feet in depth. The workings as yet are not sufficiently extensive to determine whether this feature of their intersection actually holds true on all levels. The intersection of the lodes led to a curious error when the present main adit tunnel (600 level) was run. In all the old adits above the 300 level the relatively barren Iron vein had been cut before reaching the Tomboy lode, the two being 220 feet apart on the 200 level. In the 600 adit, however, the Tomboy was first cut, and as it was not productive at this point, it was supposed by those then in charge of the exploitation to be the Iron vein reversed in dip. Consequently the adit tunnel was continued 185 feet farther to the Iron vein, which was then worked on the supposition that it was the Tomboy. It is generally barren, but on this level shows an ore body about 15 feet wide and over 100 feet in length. It is, however, a galena ore, carrying about 40 ounces of silver, and totally different from the Tomboy ore.

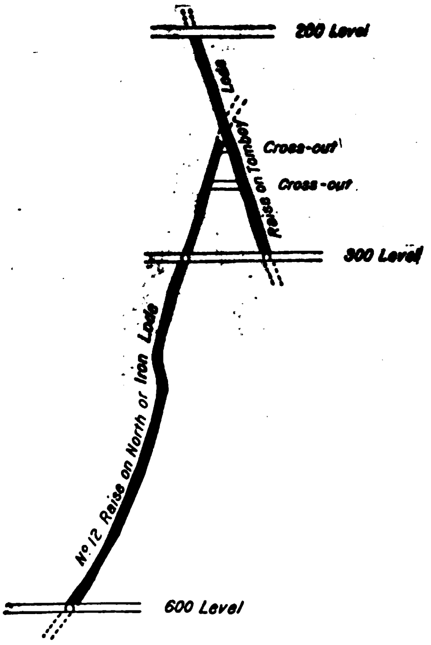

FIG. 15.—Cross section of the Tomboy and Iron lodes through No. 12 raise on the Iron lode and a neighboring raise (projected) on the Tomboy lode. Platted from notes of surveys by Mr. John Herron.

The exact nature of the intersection of the two lodes is not determinable from present exposures. In raising from the 600 level to the 200 level on the Iron vein for the purpose of connecting with the upper drifts on the Tomboy lode, it was found that these raises came out as much as 50 feet within the hanging wall of the latter lode and connection had to be made by crosscutting (figs. 14 and 15). It was noted that each of these raises passed at some point through a great mass of somewhat shattered quartz, usually about 12 feet wide, and with no regular walls. This was probably the intersection of the lodes, as indicated by subsequent surveys. One of the best pay shoots in the mine occurred at a point which was afterwards discovered to be on or near this line of the intersection. On the 300 level, northwest drift, the gradual convergence of the Tomboy and Iron lodes has been traced by crosscutting at intervals from the former to the latter. At the point where the intersection probably takes place is a confused mass of quartz, altered country rock, and ore over 12 feet wide, with irregular walls. From this ore body two veins again diverge, which may represent the northwest continuations of the Tomboy and Iron lodes. They are here small and have not yet been much drifted upon. It is at present impossible to determine the relative ages of the Tomboy and Iron lodes. It is not unlikely that their ages are substantially the same.

The contact between the San Juan breccia and the overlying massive andesite belonging to the Silverton series occurs in the Tomboy at about the 300 level, but the two rocks are not very readily distinguished under ground. It does not appear that the change in country rock has effected any noticeable change in the character or quantity of the ore.

In the general sheeted character of the fissuring, in the vitreous nature of most of the auriferous quartz and in its shattered and stained appearance, in the presence of a low-grade galena streak near the foot wall, and in the almost exclusively gold output, the Tomboy lode shows much similarity to the Camp Bird. About nineteen-twentieths of the Tomboy product is gold.

The Tomboy mill is equipped with 2 Union and 1 Blake crusher, 2 sets of rolls, 8 Huntington mills, and 24 Frue vanners. The pulp from the Huntingtons is passed over silvered amalgamating plates, which retain over 75 per cent of the gold. The Huntingtons are the equivalent of about 60 stamps, and the capacity of the mill is about 200 tons daily. The power is electricity transmitted from Ames, 12 miles distant, to a 150-horsepower motor. A Corliss engine of 120 horsepower is held in reserve.

The water supply of the Tomboy is drawn from a small lake on the eastern side of the divide, in Ouray County. It is pumped to the mine by electric power from Ames.

The Tomboy has produced from $4,000,000 to $5,000,000.

Japan mine.[1]—The Japan vein is nearly parallel with the Tomboy and lies to the southwest. It is recognized as crossing the main Tomboy adit tunnel at about 900 feet from its mouth, and therefore about 835 feet southwest of the Tomboy lode. It has been drifted on for a short distance, but in the Tomboy ground is too small to work. The workings of the Japan mine lie about one-fourth mile northwest of the Tomboy adit, and the two mines are not connected. Not much work had been done on the Japan prior to 1894.

The course of the Japan lode is about N. 47° W. The general dip is to the southwest at from 70° to 80°, although on level No. 1 the exceptionally low dip of 50° was noted.

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[1] Since this description was written, readjustment of the primary triangulation of the United States Coast and Geodetic Survey has resulted in placing the Japan and Columbia mines outside of the Silverton quadrangle. The descriptions, however, are retained as originally written.

A crosscut tunnel of about 250 feet, running a little west of north, gives access to the vein on the No. 1 level. Below this level, at intervals of 125 feet, are levels 2 and 3, worked through a shaft from No. 1 level. The lode as a rule is an unusually regular plate of ore, having an average width of about 18 inches and generally frozen to the walls. Less frequently it is a regular sheeted zone, 3 or 4 feet wide, the stringers of ore and quartz showing comb and vug structure. Even where the lode is a simple solid vein a foot in width, the walls, especially the foot wall, may show conspicuous sheeting for some distance from the ore. The hanging wall is usually smooth and regular. The country rock of the portions of the vein now worked is andesitic breccia of the San Juan series.

The ore consists of galena and sphalerite, with a little free gold, argentite, and wire silver, in a gangue of quartz, rhodochrosite, and a little fluorite. A banded structure is often very noticeable. A typical section of the vein as seen in one of the stopes is shown in fig. 5 (p. 69). In this case the stringers of barren-looking quartz next the walls appeared to be of later age than the banded ore between them.

The average value of the Japan ore is about $25 per ton. Nearly one-half of this is in gold, the other being equally divided between silver and lead. All the ore, except a little streak of rich lead ore, which often occurs in veins, is milled.

About 150 feet northeast of the Japan vein is a second parallel lode—the Morning vein—with the same general dip as the Japan. Where cut by the Mikado crosscut from the No. 1 level of the Japan, this vein is only 5 inches wide and carries galena ore, frozen to the walls. Elsewhere it is wider and often carries much coarsely crystalline pale-green and white fluorite. This lode is not worked.

About 750 feet northeast of the Morning vein the Mikado crosscut passes through a third parallel vein, here not much more than a fissure carrying some gouge. In all, the Mikado crosscut has been driven nearly 1,900 feet to the northeast in the hope of cutting the continuation of the Tomboy lode. Several small fissures, generally parallel with the Japan lode, have been cut, but none of them carry ore in commercial quantities. Apparently the Tomboy lode does not continue so far to the northwest, or else is diminished in size and changed in character so as to be unrecognizable.

The Japan and Morning veins are both faulted by the Flora vein, with a course of N. 65° E. and a dip of 55° or 60° to the southeast. This is a barren quartz vein about 2 feet wide filling a fault fissure which has thrown the southeastern portion of the Japan and Morning lodes about 16 feet to the southwest. This same vein probably faults the Tomboy lode also, in ground not yet explored, and may be connected with the failure of the Tomboy to appear in the Mikado crosscut. The position of the Flora vein is well marked on the surface, as its outcrop determines the presence of a little ravine.

About 150 feet southwest of the Japan lode lies the Whale vein, striking N. 40° W., and therefore a member of the same generally parallel system of veins to which belong the Tomboy, Iron, Japan, and Morning lodes, with others yet to be described. The dip is southwest at 75°. The Whale is a small vein, seldom over 6 inches wide, and consists of solid white quartz carrying some free gold. It has been worked near the surface and has produced some rich gold ore. It is cut in the Climax tunnel, an unused upper level lying east of the Flora vein. The Climax crosscut also continues into the Japan lode (here called the Climax) and on to the Morning vein, 170 feet beyond. The andesitic country rock between these veins shows pronounced parallel sheeting.

The Japan mill is equipped with 1 Gates crusher, 2 sets 12 by 20 Davis rolls, 6 3-compartment Harz jigs, 1 5-foot Huntington mill, 2 6-foot Wilfley concentrators, and 2 4-foot Triumph concentrators.

Power is furnished by a 50-horsepower Westinghouse motor supplied with electricity from Ames. The capacity of the mill is about 60 tons. The total product of the Japan has been about $600,000.

Argentina mine.—This is located on a very prominent lode cropping near the bed of Savage Creek, just southwest of the Tomboy and Japan mines. The strike of the lode is about N. 35° W., and the dip 75° to 80° to the southwest. The croppings, often stained black by oxide of manganese, may be traced over the ridge to the southeast into Ingram Basin and beyond the edge of the quadrangle to the northwest into Marshall Basin. It is one of the prominent group of strong, continuous, generally parallel lodes of this region, to which belong the Smuggler, Cimarron, Tomboy, Japan, and countless smaller veins. As early as 1882 and 1883 several shafts were sunk on the Argentina claim and some rich free-gold ore was taken out near the surface, but for many years the mine has been idle. In 1900, however, the Tomboy Company took hold of the property and drove a tunnel on the vein. In August a length of 800 feet had been attained, and the whole width of the lode was being milled.

The lode nowhere shows less than 5 feet of ore, and in places is 12 and 15 feet wide. The country rock is the San Juan andesitic breccia, with some massive andesite. There is no gouge and no regular walls. Stringers from the main vein-filling traverse the hanging wall irregularly, and the best ore is usually found in this mixture of stringers and country rock.

The ore shows galena, sphalerite, chalcopyrite, pyrite, and sometimes free gold, in a gangue of quartz and rhodonite. It is variable in tenor, but as a whole carries about $16, chiefly in gold, with less important values in silver and lead.

The present work is considered merely as prospecting, and the ore removed in drifting has been treated in the Tomboy mill.[1]

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[1] A tramway has since been erected, connecting the Argentina with the Tomboy mill.

Columbia mine.—This property is also on a prominent lode which lies southwest of the Argentina, and which is the southeastern continuation of the Cimarron vein in the Telluride quadrangle. The Columbia mine is at present not extensively or continuously worked. The vein as seen underground is much like the Japan, but less regular. Its strike is about N. 30° W., with a variable dip of 60° to 75° to the southwest. The ore is sometimes 2 feet in width, but more often about 10 inches. In places it is solid, consisting of quartz, galena, sphalerite, and pyrite, with little or no gouge; but often it is crushed and pinched by post-mineral movement along the fissure. As in the Japan, parallel sheeting of the walls of San Juan breccia is a noticeable accompaniment of the vein. The stringers of quartz which often fill the fissures in the sheeted country rock are practically barren.

All the ore is concentrated. The best of it carries about 1 ounce of gold, 70 ounces of silver, and 30 per cent of lead.

North Chicago mine.—This property, which has been idle for some time, lies in Savage Basin near its head, and is perhaps on the Tomboy lode. It was worked through a shaft.

ORE DEPOSITS OF THE RED MOUNTAIN REGION.

General.—Under this head will be described the various ore deposits occurring about Ironton Park and Red Mountain. They include ordinary fissure lodes and replacement deposits of more than one kind. But the bodies of ore which gave this particular region its fame are of a type less commonly met with in other districts. The ore occurs in so-called "chimneys"—i. e., nearly vertical bodies of ore roughly circular or elliptical in plan. Unfortunately, owing to the idleness of these mines, satisfactory study of the ore bodies is not at this time possible. In a few cases access was had to the old upper workings, but for information in regard to the deeper portions of the deposits recourse must be had to a few published descriptions, the annual reports made by superintendents to the directors of companies, and to information gathered from those who were familiar with the deeper mines before they shut down. The latter is sometimes conflicting, but by judiciously weighing its various sources and by making allowances for different points of view an endeavor has been made to supply as nearly as possible the unavoidable lack of observation at first hand.

The country rock in which the Guston, Yankee Girl, and neighboring mines lie is a part of the Silverton formation. It is an andesitic breccia, usually somewhat decomposed near the surface, and apparently originally of rather homogeneous character. With it are associated some flows of massive andesite. Locally the rock has been so altered by thermal action as to obliterate its original features. It is changed to a white or yellowish siliceous mass, in which the breccia structure is usually obscured or lost. Quartz is abundantly visible in it as fine veinlets and irregular bunches, and the mass generally contains much finely disseminated pyrite. The nature of this alteration has already been fully described on pages 124–131.

The Silverton breccia is cut by numerous dikes, sills, and irregular intrusive masses of andesite. Intrusive plug-like masses of monzonite-porphyry, carrying conspicuous phenocrysts of orthoclase and quartz in a fine gray groundmass, are also common. Such a mass is exposed at the roadside between the Yankee Girl and Guston mines.

The general character and distribution of the typical Red Mountain ore deposits have already been discussed (pp. 103–104), and it is only necessary in this place to proceed directly to the detailed descriptions of the various mines.

Yankee Girl mine.—The Yankee Girl ore body was discovered in the autumn of 1881 by John Robinson.[1] In 1882 it was being opened by two shafts, each about 50 feet deep. At that depth the ore is said to have been about 9 feet wide, consisting chiefly of galena with bunches of chalcopyrite, and carrying as much as 80 ounces of silver and 65 per cent of lead. The ore body was rapidly opened up and proved large and rich. In 1883, with a thousand feet of drifts and shafts, about 3,000 tons of ore were extracted, with an average value of nearly $150 per ton. The product for this year is given in the Mint report as $400,000, and the ore is said to have carried a high percentage of lead. In 1884, according to the same authority, the mine was producing about 40 tons a day, which, at $150 per ton, would be something over $2,000,000 for the year. This, however, is obviously an excessive estimate. In 1887 the output is not known, but was probably much less than $200,000. In 1890 it is credited with $1,352,994, the silver, as usual, being given at its coinage value and no return being made for copper or lead. In 1891 the product is given as $601,465 in gold and silver, and in 1892 it had fallen to $95,445. Of this amount $5,200 was in gold, $48,333 in silver (coinage value), $3,632 in lead, and $38,280 in copper. Thus these fragmentary records show that in the course of ten years' working the ore changed, within a vertical distance of 1,000 feet, from one carrying chiefly galena to one rich in copper.

This has probably been the most widely known and most productive mine in the Red Mountain district, although closely rivaled by the Guston. But it was an expensive mine to operate on account of the irregular form of its large ore bodies, the abundance and corrosive activity of its waters, and the necessity of hoisting and pumping through deep shafts. These adverse conditions, in conjunction with a falling off in the value of the ore and the decline in silver, finally caused the mine to shut down about 1896.

The Yankee Girl ore body lies in Silverton breccia (possibly extending below into the San Juan breccia), which, in the vicinity of the mine, is decomposed and weathered near the surface. Such croppings as may formerly have been visible have been covered by the shaft house and other mine buildings. The mine was formerly worked by a vertical shaft over 1,000 feet in depth, which in 1899 was nearly full of water, rendering the workings wholly inaccessible.

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[1] T. A. Rickard (Trans. Am. Inst. Min. Eng., Vol. XXVI, 1896, p. 842) states that the discovery was made in August, 1882, by Andrew Meldrum. This is apparently erroneous.

T. E. Schwarz[1] described the Yankee Girl ore in 1883 as occurring "in four chimneys, three near the south side of a dike and the fourth near the north side of another dike some distance away. The ore in each chimney is similar and often occurs in bowlder form." In 1886 Mr. S. F. Emmons made a brief visit to the mine and recorded his observations in the following notes, not hitherto published:

> The main shaft is sunk about on a level with the road, but the old tunnel runs in from the bottom of the valley below, which slopes here very steeply; the tunnel cuts the shaft about 75 feet from the surface. From the top of the shaft down to the tunnel level the ore was lead ore, mainly galena and pyrite. From the tunnel level down the ore began to change, copper coming in and lead disappearing; below the third level is practically no lead. The rich ore is now a purple copper ore with stromeyerite, copper glance, copper pyrite, and some gray copper and barite. Outside the ore body the country rock is impregnated with fine-grained pyrite. In the Orphan Boy, one of the Yankee Girl claims, is some manganese spar, but it is not at all common.
>
> The mine has six levels, the adit making the first. The sixth level is at a depth of 500 feet. The shaft has been sunk 113 feet deeper, and a station made for a seventh level, which has not yet been opened.
>
> The ore is found in several cylindrical or elliptical chimneys, called, respectively, the Yankee Girl, Orphan Boy, North, West, and South chimneys. The main shaft was sunk about in the middle of one of these chimneys—the Yankee Girl. The discovery shaft, about 50 feet north of the main shaft, was 10 feet down in this body when the mine was finally purchased for $125,000. In the first and second levels the main shaft is still in this chimney, but below it is cut at an ever-increasing distance south. The chimney is nearly cylindrical in shape, 20 to 30 feet in diameter, and consists of white quartz rock, more or less impregnated with mineral. Around this is country rock, somewhat decomposed, and impregnated with pyrite—a sort of transition material; beyond this is unaltered breccia. Dike rock, according to Schwarz, is always within 15 feet or less of the ore shoot. The west drift on each level, running off as a rule a little south of the shaft, generally cuts through the "dike rock" and finds another chimney beyond it. But the shape of the dike is very irregular; in one drift it is over 100 feet wide, in the next below almost wanting, and comes in again in the next below. According to Schwarz it sometimes runs quite flat for a considerable distance. He recognizes two dikes running in his ground, and another running from the Guston into the Robinson. I observed many joint planes or cross fractures, some showing slickensided surfaces, and these generally form walls to the ore bodies. Although these have a prevailing direction northwest, there are many other directions, and their surfaces are sometimes curving. It is my impression that such planes have admitted or given form to the ore bodies, and Schwarz admits that there is always a prominent one running with the longer axis of the ore body, which often tapers up into it when running out.
>
> Kaolin occurs, presumably pure, but resembling Chinese talc, although not so translucent. Bournonite and enargite occur in the Yankee Girl; also polybasite in the upper part.

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[1] Proc. Colo. Sci. Soc., Vol. I, 1883-84, p. 132.

In a paper published in 1888 Mr. Emmons[1] says:

> In the Yankee Girl there are several chimneys in which the ore occurs. They are of elliptical outline, the longer axis corresponding in direction with a main system of fractures running through the region. Although the striated surfaces of these planes show that there has been movement along them, there is but little evidence left of actual brecciation of the country rock, the ore solutions having completely replaced the andesitic country rock between the fracture planes which gave access to them; in places a siliceous skeleton is left, the basic constituents being replaced by vein material; in other places a solid body of metallic minerals is found, while the country rock adjoining the body of pay ore is impregnated to a considerable distance with low-grade sulphurets.

This same year (1888) Mr. Emmons paid a second visit to the Yankee Girl. He found[2] that on the sixth level, 432 feet deep according to Schwarz, the Yankee Girl ore body was connected by ore with the Orphan Boy, a small ore "chimney," lying in the upper levels about 150 feet south of the Yankee Girl. On this level the Yankee Girl ore body was elliptical in plan, 10 feet wide, and 32 feet long. At the fifth level it was nearly cylindrical, 8 to 10 feet in diameter, and nearly solid galena, passing below into "gray copper ore." Just below the sixth level occurred a "floor" or horizontal fault plane. This varied from 3 inches to a foot or more in thickness, of clayey attrition material, and frequently contained rounded masses of ore with rock centers. It dipped to the westward, sometimes as much as 25°. There seemed to him to have been some movement along this floor to the westward or downhill toward the valley, but that the ore bodies had not been much displaced. A third or "west ore body" lay to the westward of the Yankee Girl shoot, lenticular in shape, with its longer diameter nearly north and south. On the sixth level this was 2 or 3 feet wide and 8 or 10 feet long, but with rather poorly defined boundaries, the ore fading off into mineralized country rock.

Mr. Emmons records that—

> Around each chimney of ore is an envelope of "quartz." This is a blue siliceous material, sometimes granular looking, sometimes compact and almost jaspery, and yet in the mass full of cracks, and sometimes of vesicles which are filled with white kaolin. It is generally impregnated with fine-grained pyrite. The ore, moreover, fills little fine cracks or seams down to an eighth of an inch in width. These are sometimes large enough to be worth taking out in the vicinity of the ore body. Outside the "quartz" envelope comes the "white rock," which is evidently altered porphyry, which passes into a hard, compact blue rock, which is probably the less altered variety.

What was called quartz at that time in the mine, Mr. Emmons considers at the present time to have been a jasperoid or siliceous replacement of the country rock. He also states that replacement is very abundant in the volcanic breccia, the matrix being first replaced by ore, which finally coats the pebbles or fragments of the breccia.

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[1] Structural relations of ore deposits: Trans. Am. Inst. Min. Eng., Vol. XVI, 1888, p. 834.

[2] Unpublished notes.

Mr. T. E. Schwarz, for several years superintendent of this mine, has kindly furnished some important data in regard to the ore bodies. The ore in the Yankee Girl shoot, down to No. 1 level, a distance of 75 feet, was chiefly galena, and averaged 77 ounces of silver and 36 per cent of lead. From No. 1 level to No. 2 level, 80 feet, it averaged 242 ounces of silver and 29 per cent of copper, lead not being given. The galena, however, was disappearing, and the characteristic mineral from the second to the sixth levels was stromeyerite, associated with chalcopyrite, pyrite, and occasional occurrences of argentite and other rich silver ores, some of which carried bismuth. Similar changes took place in the Orphan Boy shoot, although the galena continued to greater depth. On the sixth level (432 feet deep) these two ore shoots came together, a straight drift in continuous ore connecting them. A few feet below this occurred a heavy, strong, nearly horizontal seam or slip carrying much "talcy" material.

> The rich ores of the Yankee Girl disappeared at this seam, no stromeyerite or other distinctive rich silver mineral being found below it. The main Yankee Girl ore shoot continued down through it without perceptible change of position, and was large and strong from No. 6 to No. 8 levels. The character of the ore changed, however, and "peacock copper," with pyrite and chalcopyrite became its constituents. Bornite I took to be the principal ore for large masses. To show grade of selected ore produced from richest stopes, I may note a shipment of 10 tons which carried 3,270 ounces of silver and 29 per cent of copper. A smaller lot of 7,360 pounds returned 5,301 ounces of silver and 28.75 per cent of copper.[1]

Speaking from memory, Mr. Schwarz believes that the ore in the bottom levels of the Yankee Girl was low grade and carried more pyrite than above.

These various descriptions of the ore bodies are given at some length, since they are not in perfect agreement on all points, and yet they furnish cumulative evidence of the truth of certain important features.

Mr. Schwarz[2] has also published a description of the ore bodies of which the Yankee Girl is the type. He says, in part:

> The ore occurs in "chimneys," so called, having in some cases an elliptical or a circular cross section, but more generally long in proportion to their width. The greatest length of ore body so far observed has been about 60 feet.
>
> The immediate envelope of the ore chimneys is "quartz," which is sometimes of considerable extent, while the whole is inclosed in an area of greater or less extent of andesite.
>
> The andesite is metamorphosed in proportion to its nearness to the ore chimney, showing more kaolin and quartz and less of its original structure. It thus merges into a fine-grained brown or grayish quartz, sometimes very hard and flinty, and again quite porous. In depth the quartz matrix becomes less characteristic.

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[1] Personal letter from Mr. Schwarz. It is not clear, in view of the figures just given by Mr Schwarz, just what he means by saying that no rich silver ore occurred below No. 6 level. He probably refers merely to the mineralogical change in the ore from stromeyerite to bornite, or he may mean that these high-grade lots came from above level 6. The high copper percentage, however, would not indicate this.

[2] Notes on the ore occurrences of the Red Mountain district: Proc. Colo. Sci. Soc., Vol. III, 1888, pp. 77-85.

In the case of six chimneys occurring on the Yankee Girl, Guston, and Silver Bell properties, being the only ones on which depth has been obtained, a marked increase in the silver content of the ores occurred from the surface down to 300 to 400 feet of depth.

Changes of character of ore with depth are noticeable in several chimneys, but notably so in the Yankee Girl chimney. In this case the distinctive minerals, in order of depth, have been galena, gray copper, stromeyerite, and bornite. In those chimneys in which enargite has been the surface ore no depth has yet been obtained.

The chimneys frequently change their pitch, sometimes quite suddenly. * * * A jump of 15 to 25 feet along some horizontal plane is not infrequent. * * *

Every chimney is connected with one or two cleavage or fracture planes, which bound a portion of the ore body, while on the other sides the ore merges into the quartz or andesite. These planes usually show striations slickensides, and more or less gouge material, but are not of great persistence laterally.

Horizontal planes occur of great strength, which have indirectly had marked influence on the ore bodies, changes of character occurring at such horizons.

In the Guston and Yankee Girl the increase in the amount of the copper ore with depth is notable, as is also the fact that the silver is confined mainly to such ores.

Mr. Schwarz supposed the ore to have been brought in by solutions moving chiefly along horizontal planes, perhaps bedding planes, and to have been derived from the andesite of the region. His explanation is essentially that of a rather narrowly confined lateral secretion. The maximum length of 60 feet was probably exceeded by the ore bodies worked in the Yankee Girl and Guston subsequent to 1888. One of them is reported by one who saw it to have been 140 feet in length and 20 feet wide. According to Schwarz, several carloads of ore from the Yankee Girl carried from 1,500 to 3,000 ounces of silver per ton, and one lot of about 6 tons contained 5,300 ounces of silver per ton. Such ores carried 30 to 33 per cent of copper.

According to Mr. J. Owen, who formerly worked in the Yankee Girl and is at present superintendent of the Silver Lake mines, the rich bodies of stromeyerite, which had been so productive prior to 1888, began to change, at about 500 feet in depth, to bornite, which, although lower grade, was yet good ore. At this level there was a fault encountered which threw the lower portion of the ore body to the west. Below this the deposit, according to Owen, has more the character of a vein 10 or 12 feet wide and running "north and south." It consists, near the bottom of the shaft, of large bodies of bornite, with some chalcocite, assaying as much as 57 per cent of copper. (As pure, nonargentiferous bornite contains only 55.5 per cent of copper, this assay, if correct, would indicate the presence of considerable chalcocite.) Two carloads of this ore were shipped by Owen from a winze 40 feet below the bottom of the present shaft, and it is said to be abundant at that depth. From the eleventh level ore was shipped worth from $500 to $700 per ton in silver and copper. The latter averaged about 20 per cent. No large bodies of iron pyrite were found in the Yankee Girl, according to Owen.

At present the Yankee Girl shaft is about 1,050 feet in depth. A plan of the extensive levels shows an intricate maze of workings in which no linear system is discernible. The mass of the workings lie just west of the shaft, and in plan may be roughly inclosed in an irregular triangle. A smaller extent of workings lies just east of the shaft.

Inspection of the dump, as well as inquiry, shows that there was never much vein quartz associated with the ore. The "quartz" of the miners is very largely the bleached and silicified country rock adjacent to the nearly solid bodies of ore. Where vein quartz occurs it usually carries iron pyrite. Barite, in small masses and crystals, occurs embedded in the bornite. The chalcocite is generally intimately associated with small amounts of chalcopyrite. Some specimens show that the ore has been fractured and recemented by veinlets of calcite. The ore minerals observed on the dump were galena, sphalerite, chalcocite (stromeyerite), bornite, chalcopyrite, and pyrite. Cosalite was recognized in 1884, therefore, in the upper part of the deposit, and was analyzed by A. H. Low,[1] as follows:

Analysis of cosalite from Yankee Girl mine.

Constituent.	Per cent.	Constituent.	Per cent.
Bismuth	36.22	Iron	4.48
Silver	8.70	Sulphur (by difference)	18.64
Lead	28.22		100.00
Copper	3.74		

Proustite and polybasite also occurred occasionally in the Yankee Girl ore bodies.

All accounts of the Yankee Girl mine unite in emphasizing the chemical activity of the underground waters encountered in the workings. According to Schwarz[2] they contained "24 grains per gallon of sulphuric acid (SO_3)." Candlesticks, picks, or other iron or steel tools left in this water become quickly coated with copper. Iron pipes and rails were rapidly destroyed, and the constant replacement of the piping and pumps necessary to handle the abundant water was a large item in the working expenses. All agree in stating that the water entered far less abundantly below the sixth level. Some who worked in the mine express it as being "not so bad" below that level. But closer inquiry usually elicits the information that it was less abundant but as much or even more corrosive than at the upper levels.

The product of the Yankee Girl is roughly estimated at about $3,000,000.

Robinson mine.—This mine is really a part of the Yankee Girl, both being worked together. It has produced some good ore, but little could be ascertained concerning the details of its occurrence. According to Mr. J. Owen, the ore changed to iron pyrite, but the depth at which the change took place was not stated by him. The shaft of the Robinson is sunk alongside one of the mounds of siliceous altered breccia characteristic of this region.

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[1] Proc. Colo. Sci. Soc., Vol. I, 1884, p. 111.

[2] Trans. Am. Inst. Min. Eng., Vol. XVIII, 1889-90, p. 139.

It is stated by Mr. Owen that a distinct vein or fissure was followed from the Guston into the Robinson, and was demonstrated by drifting to extend into the Genesee-Vanderbilt. The same fissure was cut by an east crosscut in the Yankee Girl.

Guston mine.—This ore deposit, just north of the Yankee Girl, was opened shortly after the latter, in 1882. The ore body as exposed at that time is said to have been 5 feet wide and carried 58 ounces of silver per ton. It was chiefly galena, with some copper mineral, probably tetrahedrite. In 1883 the mine produced, according to the Mint reports, $57,500. In September, 1887, steps were taken to form the present New Guston Company, Limited, of London, England, and the mine was closed until June, 1888, when work was resumed with Mr. T. E. Schwarz as superintendent, and extensive bodies of ore were found on the third, fourth, and fifth levels, yielding in carload lots up to 450 ounces of silver per ton. The depth of the mine at this time was only 288 feet, while the Yankee Girl was down 1,050 feet. The product for 1888 was about $130,000. In 1889 ore was produced to the value of over $390,000, and work was carried to the sixth level, 378 feet from the surface. Mr. James K. Harvey this year succeeded Mr. Schwarz as superintendent. At the close of 1889 the mine had already paid dividends amounting to £56,374 (about $274,000). In 1890 the shaft was sunk to the seventh level and extensive stoping carried on in the upper levels. Ore to the amount of 4,469 tons was sold, which realized $491,336 (£101,098), or an average of nearly $110 per ton after deducting treatment charges. Several carloads of this ore carried from 600 to 1,400 ounces of silver per ton. The product this year was principally from the stopes of the fifth and sixth levels. The ore carrying most silver was encountered on the fifth level north of the shaft, and contained 12 per cent of copper. At this time there were from 200 to 300 men employed in the mine, and the small settlement of Guston had grown up in the vicinity of the shaft. The water pumped from the mine this year was about 35 gallons per minute, and is said to have been charged with sulphuric acid from oxidation of pyrite. The Mint reports credit the mine with a total output of 864,768 ounces of silver and $57,500 in gold for 1890. The product in copper is not given. In 1891 the main shaft had reached the ninth level, about 678 feet below the surface, and the water had increased to about 50 gallons per minute, being of the same corrosive character as that found in the upper levels. The ore raised this year amounted to 11,723 tons, which realized $824,467, or an average of over $70 per ton, net value. The cost of mining was nearly $19 per ton, while during the preceding year it had averaged about $32 per ton. The decrease in the price of silver was already affecting the profits of the company. In 1892 the ore raised amounted to 14,291 tons, which realized approximately $247,232, or an average of only about $17.40 per ton. The cost of mining was about $13 per ton. This great decrease in value was due not only to general fall in the price of silver, but to a falling off in the grade of the ore. The shaft had been sunk to the tenth level, but no important bodies of ore were discovered in the 200 feet between the eighth and tenth levels, and the product was chiefly from the nearly worked-out stopes of the upper levels, from No. 3 to No. 7. In 1893 the shaft was carried down 136 feet below the tenth level and a crosscut started on the eleventh level. The ore raised amounted to 7,280 tons, which sold for $18.40 per ton. The water now pumped from the mine amounted to 60 gallons a minute. In 1894 a large quantity of ore was extracted, chiefly from the ninth to the twelfth levels, of which the greater part, being low grade, went to the Silverton matte smelter, then beginning operations. In 1895 the maximum tonnage for any year—14,833 tons—was extracted from the mine, but the average value was lower than ever before. The annual tonnage, average sales value of the ore per ton (gross value less cost of treatment), average cost of mining per ton, and amount of dividends paid, covering the eight years in which the mine was in most active operation, are shown in the following table, compiled from the annual reports of the directors of the company:

Tonnage, ore values, cost of mining, and dividends of Guston mine.

Year.	Ore raised.	Average sale value per ton.	Average cost of mining per ton.	Amount of dividends paid.
	Tons.			
1888	315	$363.25	$53.50	$77,941.90
1889	2,882	131.50	32.60	181,875.00
1890	4,469	109.80	32.25	315,250.00
1891	11,723	70.65	18.90	426,800.00
1892	14,291	17.40	13.10	146,712.50
1893	7,280	18.40	17.30	....
1894	13,334	12.80	9.60	....
1895	14,833	10.70	10.20	....
Total	69,127	[a] 91.81	[a] 23.43	1,148,579.40

[a] Average.

In 1897 the mine was compelled to cease operating, the low grade of the ore and the decline in the value of silver having acted together to render further work unprofitable. The total output since 1888 has considerably exceeded $2,500,000, of which nearly half was distributed in dividends. In all, 14 levels had been worked and a depth of nearly 1,300 feet attained. To free the mine from water at this depth the pumps were required to raise over 100 gallons a minute and great care and constant attention was required to prevent the destruction of the pumps and column by corrosion.

When visited in 1899 the mine was filled with water to the second level, 114 feet below the surface. The level of this water fluctuates with the seasons, and in spring sometimes rises to the first level, 50 feet from the surface. As the deeper workings are wholly inaccessible, the following description of the ore bodies is drawn from the annual reports of the superintendents, Messrs. Schwarz and Harvey, and from personal conversation with men who worked in the mine.

In their general shape the ore bodies resembled those of the Yankee Girl. They were roughly ellipsoidal masses standing nearly vertical, and consisting of nearly solid ore with very little gangue, surrounded by altered country rock impregnated with pyrite. The actual sizes of these masses of ore are difficult to ascertain at the present time. Some of the stopes were nearly 200 feet in length and several hundred feet in height. The width of the ore varied greatly in different bodies and in different portions of the same ore mass. Widths of from 20 to 30 feet appear to have been not uncommon.

The ore-body stope on the seventh level was, in 1892, 45 feet in length and 94 feet average height. The width of the ore for a distance of 20 feet was 14 feet; elsewhere less, and irregular. The ore from this stope carried from 20 to 80 ounces of silver and 0.3 ounce of gold per ton, with from 5 to 8 per cent of copper. The middle stope on the same level had a length of 116 feet, an average height of 87 feet, and an average width of ore of 22 feet. Its ore carried from 15 to 35 ounces of silver and 0.2 ounce of gold per ton. These are given simply as examples of typical stopes which produced large amounts of rather low-grade ore.

These ore bodies usually occurred along what was termed the "ore break," a zone of altered, disturbed, and more or less broken country rock, intersected by slip planes and containing much kaolin, as well as soft attrition material. This ore break is said to traverse the Guston claim from end to end, which would give it a course of from 20° to 30° east of north and to be, in places at least, nearly 60 feet in width. From levels 2 to 7, a depth of 364 feet, this ore break dips steeply to the east; but just below the seventh level a slip or fault was encountered dipping 45° to the west, which cut off the ore entirely. By following the soft clay gouge which occupied this fracture plane the ore break was found again below, lying from 30 to 50 feet to the westward. It here dipped steeply westward and did not carry much ore. It was not until the tenth level was reached that its dip again became easterly and it resumed the character which it had had above the seventh level. The ore in this level also was better, or at least in larger bodies, than anything hitherto found below the seventh level.

The ellipsoidal or irregular ore bodies were nearly always found in connection with this ore break, but they were most irregularly placed and were found only by persistent and thorough prospecting, partly with the diamond drill. In general the longer axes of the ellipsoids appear to have been nearly parallel with the trend of the ore break. Individually, however, the ore bodies show much variation. Thus, on the thirteenth level a streak of ore is recorded as bearing N. 30° W. They were commonly found by drifting along the "soft ground," presumably fracture planes associated with attrition material and kaolin. A plan of the underground workings of the Guston mine (Pl. XV) shows a highly intricate and irregular maze of drifts and crosscuts running out in all directions from the shaft. The map, however, shows distinct evidence of a general elongation of the ore bodies, or of the ore-bearing ground, along an axis bearing about N. 20° E. As shown by the longitudinal section of the mine, the stopes attained their greatest aggregate length, about 600 feet, on the fifth level, and grew shorter below. Longitudinal and transverse sections of the "main ore body," compiled from a mine map made in 1890 and from the annual reports of the company, are shown in fig. 16. The transverse section was evidently intended to show the general position of the so-called ore break, and not of the actual ore bodies.

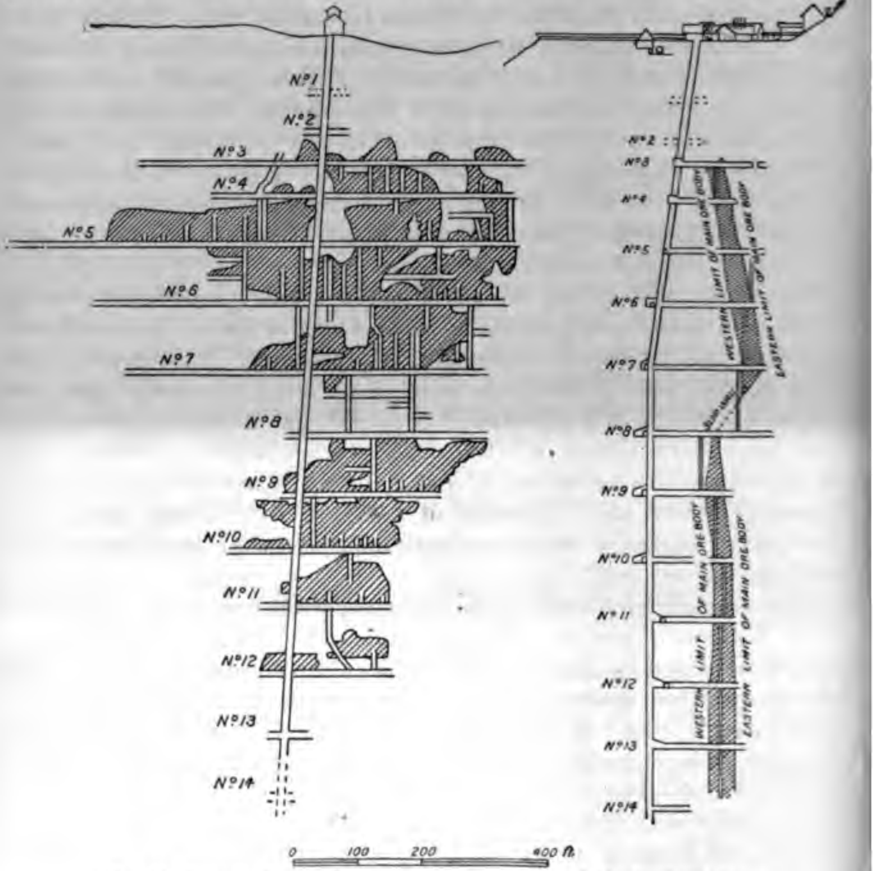

FIG. 16.—Longitudinal and transverse sections through the Guston mine.

One of the most interesting and important facts in connection with the Guston, as well as with other mines of this district, is the change in character of their ores with depth. The galena ore of the main ore body, carrying from 50 to 60 per cent of lead and from 30 to 40 ounces of silver, continued down to the second level, or a little beyond, where it is said to have changed rather abruptly to high-grade stromeyerite. Galena, however, occurred in the mine in considerable quantities down to the fifth level, 288 feet in depth, and in decreasing amounts to greater depths. Some heavy galena, carrying from 100 to 175 ounces of silver, is known to have occurred at a depth of 212 feet. With increasing depth stromeyerite, or argentiferous chalcocite, became the characteristically rich ore of the mine, associated with pyrite and chalcopyrite. Some of this was very rich, and in 1891 some ore from the sixth level (378 feet) carried as much as 15,000 ounces of silver and 3 ounces of gold per ton. The lowest-grade ore in the deeper workings was pyrite, which usually carried less than 20 ounces of silver and a fraction of an ounce of gold per ton, and from 3 to 5 per cent of copper, probably from admixture of chalcopyrite. The chalcopyrite was higher grade, usually carrying from 12 to 45 ounces of silver and a fraction of an ounce of gold per ton, and from 8 to 12 per cent of copper. Even in the best stopes of the fifth and sixth levels there was always more or less chalcopyrite and pyrite associated with the rich stromeyerite, the lower-grade ores apparently often prevailing on the peripheries of the larger ore masses.

Below the slip plane, which occurred just below the seventh level, at about 500 feet in depth, the ore was harder and more compact and stromeyerite was not found in any quantity, the ore down to the tenth level consisting chiefly of large masses of low-grade pyrite, with some bornite and chalcopyrite. The pyrite rarely carried as much as 20 ounces of silver, with a little gold and copper. Some bornite found on the ninth level (678 feet) carried from 125 to 450 ounces of silver and one-fourth to one-half ounce of gold per ton, with 25 to 50 per cent of copper. This was associated with chalcopyrite carrying 16 to 75 ounces of silver and gold up to 1 ounce per ton, with from 8 to 15 per cent of copper, and with pyrite carrying up to 15 ounces of silver per ton, with a little gold and copper. In both the ninth and tenth levels small quantities of ore were frequently met with carrying free gold, assays from level 9 giving as much as 29 ounces of gold per ton.

The ore of the eleventh level was similar to that of the tenth, but, as in all these lower levels, the rich bornite bore a smaller proportion to the low-grade pyrite and chalcopyrite than did the stromeyerite and galena of the upper workings. The ore in the stopes connected with these levels varied in width from 18 inches up to 25 feet. Some free gold was seen in barite, associated with the bornite. On level 12 ore occurred in large solid masses, one being known to be 72 feet in length, with a maximum width of 37 feet. But it was chiefly low-grade pyrite containing occasional nodules of bornite and chalcopyrite, usually with some barite. Substantially identical ore was found on the thirteenth level.

Through the kindness of Mr. Bedford McNeill, of London, liquidator of the New Guston Company, the following notes, dated March 13, 1900, were obtained from Capt. James K. Harvey, formerly superintendent of the mine:

> Galena ore was most abundant in the superficial workings, it having been met with almost at surface, and continued down to the fourth level. The ore contained from 8 to 50 per cent lead; silver, 9 to 30 ounces; gold, trace per ton.
>
> At the third level chalcopyrite and chalcocite were discovered, and continued down to where the fault was encountered, a few feet underneath the floor of the seventh level. Contents of ore: Copper, 5 to 15 per cent; silver, 25 to 700 ounces; gold, 0.1 to 3 ounces per ton. A few cars were shipped (about 10 tons to the car) that ran over 1,200 ounces silver per ton, with a corresponding gold increase.
>
> From the third to the sixth level the ore occurred in the form of a chimney, its dimensions being from 12 to 15 feet in length and width at the third, fourth, and fifth levels, to 20 to 30 in length and width at and over the sixth level. Underneath the sixth level the ore lengthened south approximately 200 feet, with a width of from 3 to 30 feet.
>
> Solid bodies of iron pyrites were discovered at the sixth level, and continued to the deeper workings. Contents: Silver, 4 to 20 ounces; copper, 1 to 3 per cent; gold, trace to 0.20 ounce per ton.
>
> Bornite was met with in quantity between the ninth and twelfth levels. Contents: Copper, 18 to 25 per cent; silver, 60 to 175 ounces; gold, one-fourth to 1¼ ounces per ton. Free gold was found occasionally with the bornite; that is to say, on the fluorspar[1] associated with the bornite. No free gold was seen above the ninth level, or in any other instance.
>
> There was but little change in the volume or character of the water. It was destructive to pumps and column if they were not properly protected.
>
> Generally speaking, the inclosing porphyry was more decomposed where the ore was most compact and richest in its metallic contents.

From the foregoing it appears that there was first an increase in the value of the ores down to the sixth or seventh level, and then a sudden falling off in value at the slip-plane below the seventh level. Below this occurred a diminution in the richness of the ore down to the bottom of the mine. The characteristic ore minerals, in the order of the depth at which they prevailed, were galena, stromeyerite (pyrite?), bornite, chalcopyrite, and pyrite. But this succession is true only in general terms. Sudden and perplexing changes in the value and mineralogical composition of the ore occurred within the individual ore bodies at all levels, and the various minerals named overlapped in most complex fashion, although the bornite apparently had a definite upper limit and the stromeyerite a definite lower limit. Of all the ore minerals pyrite appears to have had the greatest vertical range, and it undoubtedly formed an increasing proportion of the ore with depth. The highest values in silver and gold were found in connection with high percentages of copper.

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[1] Barite ? (F. L. R.)

According to Mr. Terrill, at present in charge of the mine, good ore, consisting of argentiferous bornite, was struck in the fourteenth or bottom level, but was never extracted. Had there been any considerable body of high-grade ore revealed, however, it is hardly probable that the mine would have shut down, no considerable loss in its operation having been incurred and no assessments having been levied on the shareholders when work ceased.

Mr. S. F. Emmons made a brief visit to the mine in 1888 and has recorded his observations in unpublished notes. He visited a new find of ore on the third level, which had been overlooked by the former owners. This was a solid mass of chalcopyrite mixed with tetrahedrite and galena and carrying up to 750 ounces of silver per ton. He found that this ore body, with a strike of N. 30° E., and dipping from 30° to 45° to the northwest, was limited on its foot-wall side by a distinct plane showing fault movement. According to Mr. Emmons, the sheeted structure of the original country rock, which had been replaced for a width of about 10 feet by ore, was still recognizable in the latter. The ore body, which was not more than 10 or 15 feet long, graded into quartz, clouded with snow-white kaolin, and this in turn into altered country rock or "white rock."

Genesee-Vanderbilt mine.—The original Vanderbilt shaft was sunk just southwest of the Yankee Girl, in one of the characteristic siliceous knolls of the district. This consists of a hard, quartz-like rock, in which can still be detected outlines of porphyritic crystals of feldspar, now wholly decomposed, In some places the original rock is practically wholly replaced by quartz. In the Mint report for 1882 it is noted that the Genesee, then opened by two shafts 15 feet and 20 feet deep, showed a body of galena 3 feet thick, associated with "copper," the whole carrying from 15 to 40 ounces of silver per ton. The "copper" was probably chalcopyrite or tetrahedrite. In 1888 the product of the Vanderbilt as derived from the same source was $72,672. It was subsequently found that the Vanderbilt and Genesee ore bodies were identical, or at least so closely associated that it was impracticable to work them separately, and the mines were therefore consolidated. The present workings (fig. 17), begun in 1891, consist of a tunnel 820 feet in length, connecting with the old shaft through stopes, and a second shaft, 700 feet in depth, sunk near the end of the adit tunnel. Levels were run at 300, 400, 500, 600, and 700 feet below the tunnel level. In 1899 this shaft was filled with water to within a few feet of the collar. Although the mine has produced some good ore, it is said to have been on the whole unprofitable. The ore was of a lower grade than that in the Guston and Yankee Girl, and the profits accruing from the exploitation of one ore-body were usually more than expended in searching for the next one. Work was finally suspended in 1896.

In 1899 a little ore, consisting chiefly of galena and sphalerite, was being taken out by leasers above the adit level. Access was gained to one large stope extending nearly to the surface where the original Vanderbilt shaft was sunk. The ore body that once filled this stope was evidently of lenticular form, the maximum dimension nearly vertical, and the mean diameter nearly north and south. Around the periphery of the lens the ore body wedged out completely. I was unable in the accessible portions of the stope to recognize any dominant fissure of which the lens of ore might be considered as filling an enlarged portion. Nevertheless it was by following the so-called slips or gouges in the country rock that the ore bodies were always discovered when not found by drilling (fig. 18).

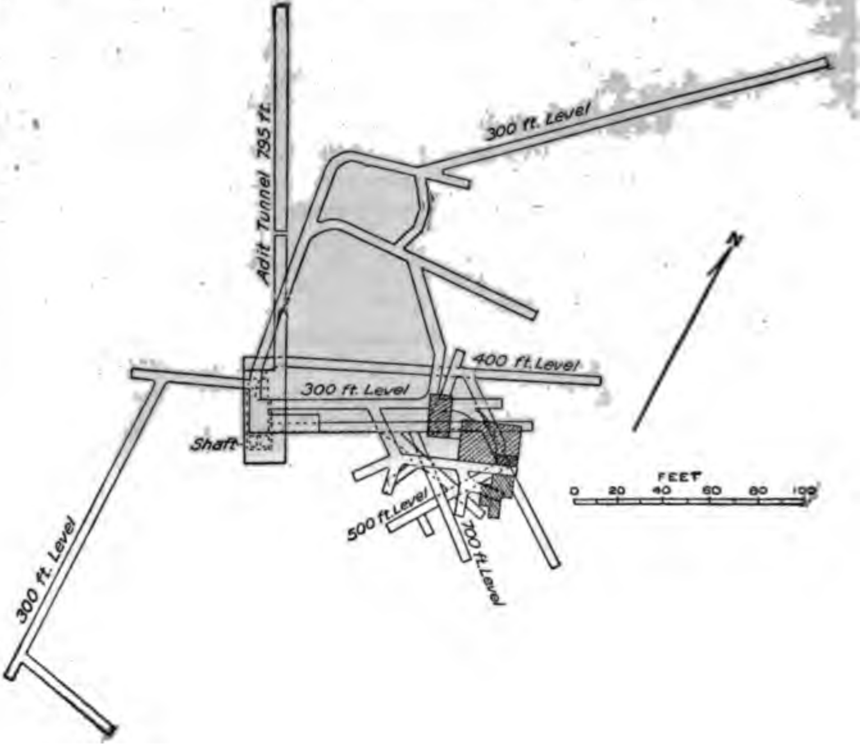

FIG. 17.—Plan of a portion of the underground workings of the Genesee-Vanderbilt mine.

Mr. T. E. Schwarz has pointed out that the principal "ore break" of the Genesee-Vanderbilt turned through an angle of about 140° in passing from the surface down to the 600 level. This is indicated in fig. 19, taken from Mr. Schwarz's paper.[1]

According to Mr. Otto J. Schulz, of St. Louis, at present trustee of the Genesee-Vanderbilt mine, there were four separate pay shoots on the surface, only one of which was explored to the 700 level. The best ore occurred at a depth of about 250 feet below the collar of the main shaft, and extended down to within about 20 feet of the 300 level.

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[1] Trans. Am. Inst. Min. Eng., Vol. 26, 1896, p. 1058.

This ore was solid and contained little waste. Its value is shown in the following table, compiled from data furnished by Mr. Schulz:

Assay contents per ton of ore from Genesee-Vanderbilt mine.

Year.	Ore.	Gold.	Silver.	Lead.
	Tons.	*Ounce.*	*Ounces.*	*Per cent.*
1893 *a*	1,525	0.2	30.4	1.6
1894 *a*	2,153	.4	45.9	3.3
1895 *b*	5,939	.2	39.8	3.9
1896 *c*	3,005	.07	18.1	.06

a From 300 level.
b About two-fifths from 500 level and rest from upper workings.
c From 500, 600, and 700 levels. Output for 2 months only.

It is rather difficult to account for the low percentage of lead and the very small amount of copper in these assay returns, as the silver was probably associated with one or both of these metals.

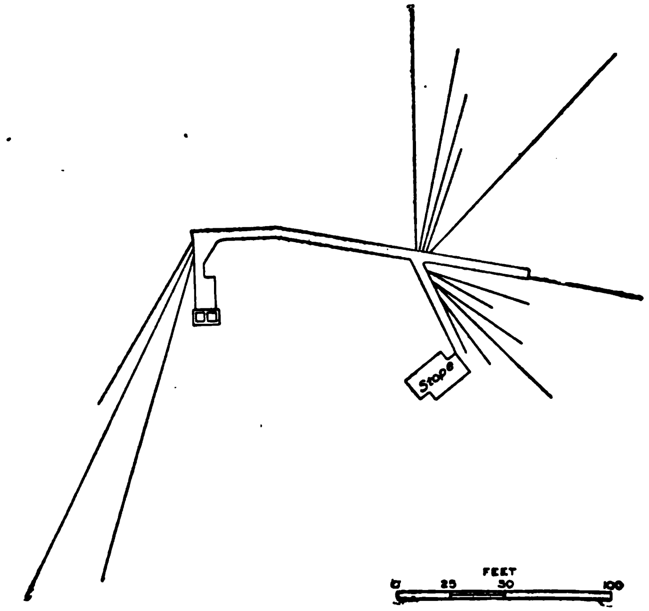

FIG. 18.—Plan of fourth level of the Genesee-Vanderbilt mine, showing method of prospecting for ore bodies with the diamond drill.

The value of the ore, never high grade as a whole, fell off with increase of depth below the 300 level, depreciating rapidly below the 500 level, and changing near the 700 level to large bodies of low-grade pyrite.

Near the surface, in the old workings, the ore is said to have been oxidized and soft, changing to galena at about 100 feet in depth.

Particulars concerning the mineralogy of the ore of the Genesee-Vanderbilt are now difficult to obtain. It is said to have contained considerable lead from top to bottom, which statement, however, is not fully borne out by the records furnished by Mr. Schulz. Cosalite is recorded as having been an important constituent of the ore. Some small caves containing stalactites of pyrite occurred in the ore bodies, but it is not known at what depth. Specimens of ore said to have come from this mine and preserved in the mine office showed some very argentiferous bornite, a slightly argentiferous sulpho-bismuthite of lead containing a little copper and corresponding in

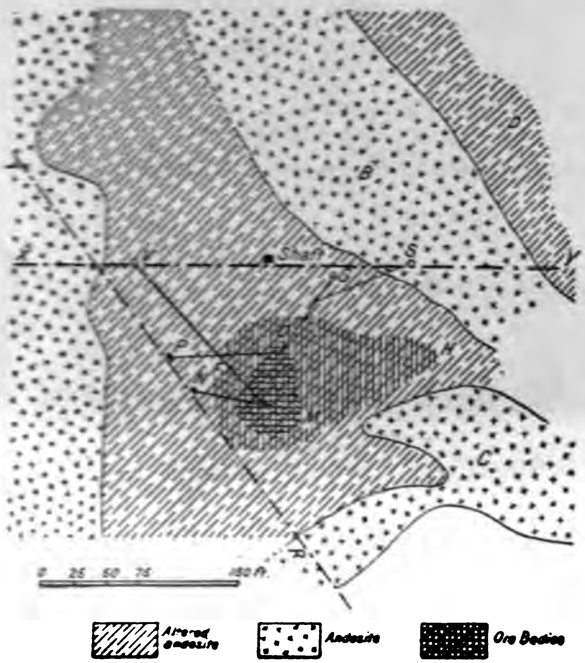

FIG. 19.—Sketch plan showing changes in position of the Genesee-Vanderbilt ore bodies, with depth. *X-Y*, surface outcrop of ore break; *V*, *G*, *S*, surface outcrop of ore bodies; *M*, *O*, position of same ore bodies on 300-foot level; *P*, *N*, position of same ore bodies on 600-foot level; *T*, *R*, ore break on 600-foot level (after T. E. Schwarz).

physical properties and appearance to cosalite, and some small crystals of ruby silver (proustite).

The total output under the old Vanderbilt Company of Red Mountain is not known, although the Mint reports credit the mine with $72,672 in 1888. The output of the Genesee-Vanderbilt Company from 1891 to 1896 amounted to about 12,622 tons of ore, containing 2,884 ounces of gold, 436,675 ounces of silver, 702,183 pounds of lead, and 30,520 pounds of copper.

The water encountered in the Genesee-Vanderbilt was of the same corrosive character as that met with in the Yankee Girl and Guston.

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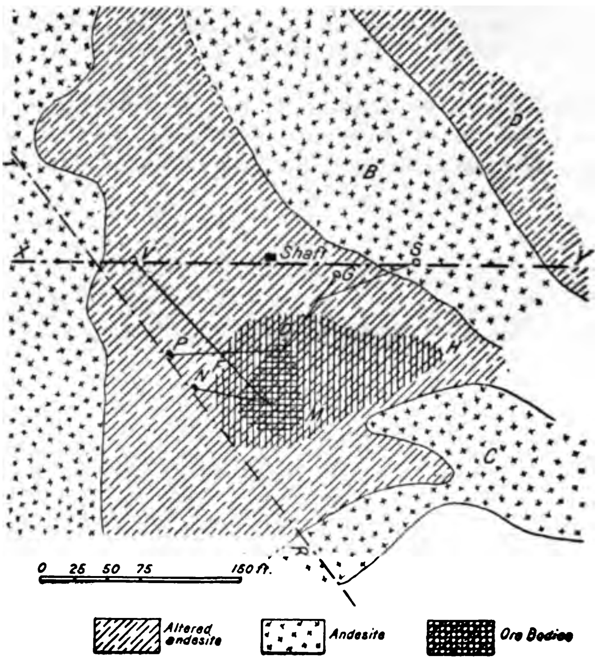

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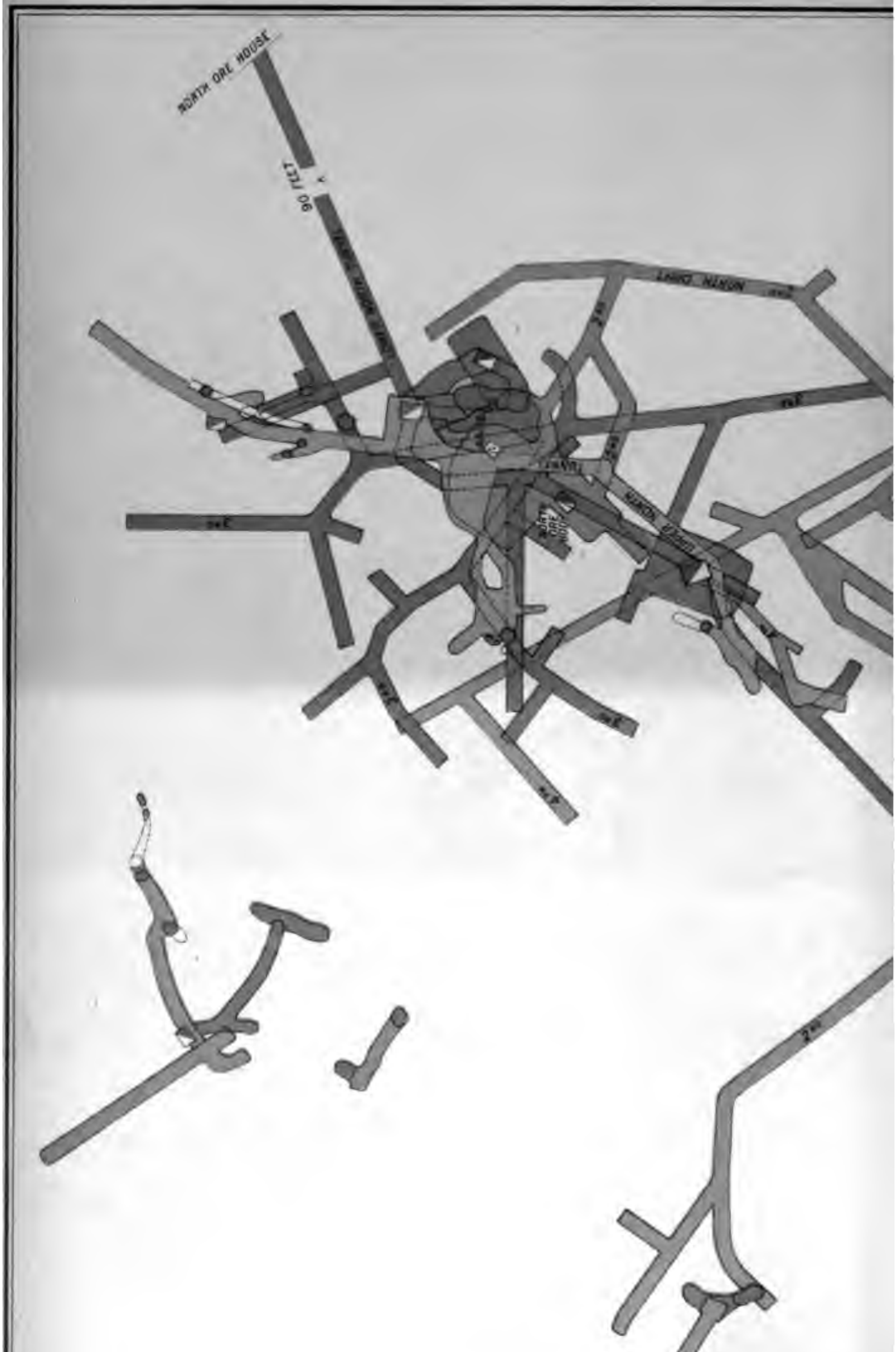
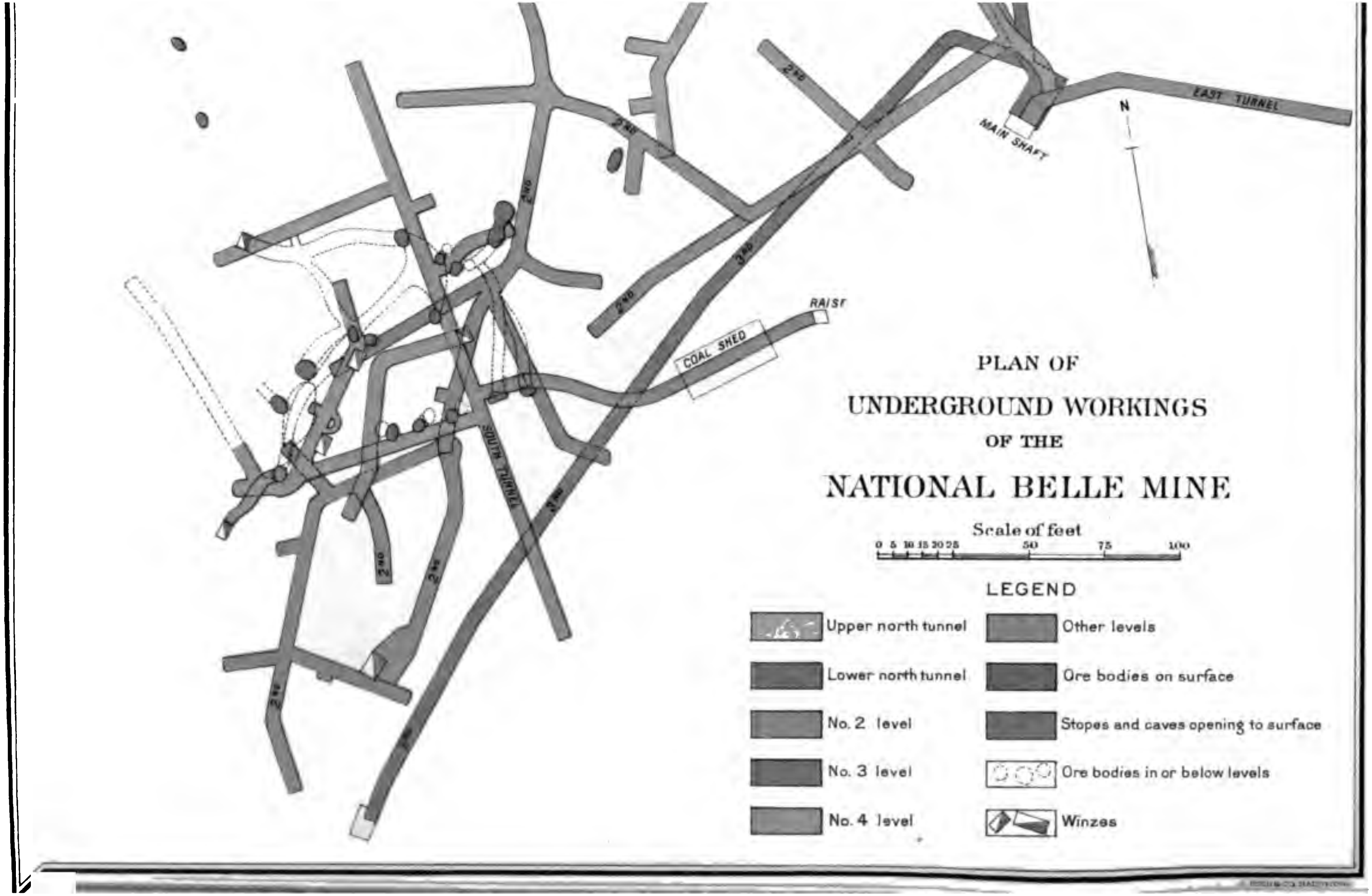

NORTH ORE HOUSE
90 FEET
NORTH DRIFT
NORTH ORE HOUSE
3rd
2nd



PLAN OF

UNDERGROUND WORKINGS

OF THE

NATIONAL BELLE MINE

Alexandra mine.—This is situated on the slope of Red Mountain, a few hundred feet above the Guston. The earlier workings are in one of the siliceous mounds common in this region, this one forming a small, elongated ridge, striking S. 85° W. The upper workings are reached through a tunnel. These seem to have two or more of the usual lenticular, nearly vertical ore bodies. One small one, stoped at the tunnel level, was elliptical in plan, the longer diameter striking N. 35° W. The ore pinched at the ends, but a small fissure, filled with kaolinite, can be seen continuing on into the country rock. The ore left in this stope is a fine-grained aggregate of pyrite, galena, and sphalerite, with specks of kaolinite. The country rock near the ore bodies is much altered, contains much kaolinite, and is thickly impregnated with fine pyrite. The ore is, in part at least, a replacement of the andesitic country rock.

About 400 feet below this woikings is a second tunnel, from which issues a strong stream of highly ferruginous water. This tunnel is now only partly accessible. It runs through a mass of bleached and altered andesitic breccia, now changed in places to an aggregate of barite, kaolinite, and pyrite. As the mine was abandoned in 1899 or 1900, no information could be gained concerning its output or the portions of the workings not now open.

Grand Prize mine.—This property, a few hundred yards north of and about 150 lower than the upper Alexandra tunnel, is abandoned and at present wholly inaccessible. Its dump shows the usual materials common to the mines of the vicinity.

National Belle mine.[1]—The croppings of the bleached and silicified country rock associated with this ore body form a prominent knoll, over 200 feet in height, on the northwestern outskirts of the settlement of Red Mountain. The principal mine buildings, adits, and main shaft (490 feet deep), are on the eastern side of this knob, close to the railway. The mine was closed and deserted in 1897, and the superficial workings only were accessible. A plan of the workings, from a mine map made in 1890, is shown in Pl. XVI.

The first extensive development was in 1883, when about 980 tons of ore were produced, valued at nearly $70,000. This occurred chiefly in an oxidized form in caves, as carbonate of lead, one of which, occurring about 22 feet below No. 2 level (fig. 20), is known to have been 40 feet long, 20 feet wide, and 10 feet high. This cave ore carried from 5 to 7 ounces of silver and from 15 to 60 per cent of lead. For 1890 the product is given as $87,591, of which $4,500 was in gold, $29,091 in silver at coinage value, and $54,000 in copper. It is evident that the output for this year was chiefly from the lower workings, in unoxidized, relatively low-grade enargite and pyrite. In 1891 the property came into the possession of the American Belle Mines, Limited, a London company, which operated the mines until 1897. The report of the Director of the Mint for 1891 credits the mine with a product of $145,721 in gold and silver only, with no returns for copper. Since the sale of ore for this year yielded the company in the neighborhood of $110,000, the foregoing output probably includes both copper and lead. At this time, however, the lower-grade copper ores could not be handled, as the nearest point at which they could be smelted was Denver, 500 miles distant. It was not until 1892 that these ores could be treated in the Standard Smelter, at Durango.

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[1] This mine is now often called the "American Belle mine," from the name of the company which last operated it, but the company's reports always refer to it under its original name, National Belle. The attempts sometimes made to change the names of mines with change of ownership are usually to be deplored, especially when, as in this case, the old name is well known in mineralogical literature.

Mr. S. F. Emmons visited the mine in 1886, and the following facts in this paragraph are taken from his unpublished notes: He found that the mine had been opened very irregularly, chiefly by tunnels run into the knoll, with overhead stopes. The ore chimney was irregular, containing oxidized ore ("sand sulphate"), with kaolin in seams and vugs. The ore was confined to the quartzitic rock, the porphyry adjoining it being impregnated with unoxidized fine pyrite, as in the Yankee Girl. It seemed to follow two general fracture planes running at right angles to the main direction of fracturing, viz, N. 10° W. He suggested that the copper sulphates had been leached out first, leaving the relatively insoluble lead salts and open spaces. Mr. Emmons did not visit the lower part of the mine, which he was informed produced a low-grade enargite carrying chalcopyrite. The caves characteristic of the upper workings were said not to occur in the lower workings. Schwarz,[1] in the paper already referred to, gives

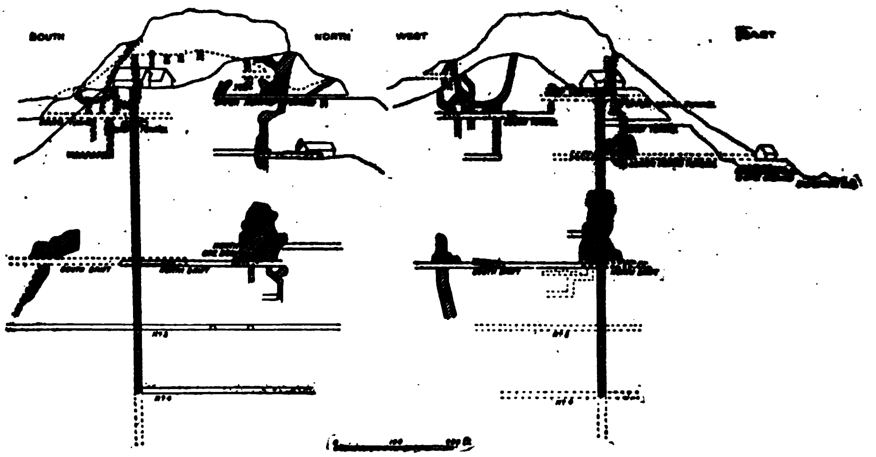

FIG. 20.—Sections through the National Belle mine, showing ore bodies stoped and natural ore caverns.

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[1] The ore deposits of Red Mountain, Ouray County, Colo.: Trans. Am. Inst. Min. Eng., Vol. XVIII, 1889-90, pp. 139-145.

a description of the secondary or oxidized ores of the American Belle and neighboring mines. They "occur above a former water line, either attached to walls of caves, as broken detached masses, or as a bed of clayey mud or sand, more or less completely filling the cave. The cave formation is identified with the massive outcroppings or knolls of silicified andesite ordinarily termed 'quartz.' These knolls * * * present a rough mass of quartz, cut up by cross fractures, and showing small vugs and cavities on the exposed cliff faces. The ore-bearing caves, which ramify throughout the mass, generally come to the surface along the cliff base." The caves are stated to come together in depth. The ores were mainly carbonates of lead and iron, with iron oxide, lead sulphate, and arsenates. Kaolinite and zinc blends were common. Galena occurred, but usually as a residue core. Such were the ores of the National (American) Belle, Grand Prize, and Vanderbilt mines, according to Schwarz. He briefly summarizes the characteristics of these secondary ores as follows:

1. The secondary ores are richer than the sulphide ores occurring below them.
2. The ores of adjoining or connecting caves are sometimes greatly different in grade.
3. In some cases the formation of the caves along fracture or cleavage planes is evident, but in others all traces of such planes are quite obliterated.
4. The cave walls are a porous sandy quartz, the sand from the disintegration of which forms part of the cave filling.
5. The line of change from oxidized to unoxidized ores, or the former water level, is very marked. It varies as much as 100 feet in elevation in properties within 1,000 feet of each other, rising to the south and west. The quartz outcrop rarely rises more than 200 feet above it.
6. In isolated cases may be found masses of the unoxidized ore, the enargite (i. e., in National Belle), above the line of change, in the vicinity of the secondary ores.

Mr. Schwarz ascribes the formation of the caves and the secondary ores within them to "surface waters" which "dissolved" sulphide ores and country rock as they moved along fracture planes.

In 1899 no thorough examination of the mine was possible, the croppings and an adit tunnel constituting the only accessible places for observation. The knob, or "blow-out," as the miners commonly term it, is in many places plainly an altered igneous rock, probably andesite or andesitic breccia. But the material in which the original porphyritic structure is still recognizable passes with no discoverable line of demarcation into a rock consisting chiefly of quartz, in the condition of a fine-granular crystalline aggregate. On the northwestern side of the knoll the country rock was originally a monzonite-porphyry mass of the same kind as that exposed just south of the Yankee Girl, or forming the cliffs just east of Summit Station. This intrusive rock has been altered in a similar manner to the andesitic breccia. The comparatively fresh facies in which the orthoclase and quartz phenocrysts lie in a fine greenish groundmass may be traced into a medium stage of alteration in which the orthoclase phenocrysts are still recognizable from their outlines, although changed to kaolin and diaspore, and finally into a white siliceous rock in which nearly all, or quite all, traces of original structure are lost. The exact character of this alteration has already been discussed on page 126. The silicified material of the knob is most irregularly and thoroughly fissured. The larger fissures often expand into irregular caves, which, as far as could be seen with the limited opportunities for observation in 1899, did not run in any single dominant direction. A few of the smaller caverns only, near the surface, could be seen. These were lined with crumbling, rust-colored, oxidized ore, beneath which there was often unaltered galena. Sometimes these caves are lined and partly filled with a light, porous, pumiceous sponge of quartz. This is not the cellular, honeycombed quartz resulting from the removal of ore by oxidizing waters, but is an original spongy crystallization of minute quartz crystals, with some interstitial kaolin. It forms a light friable mass that is strongly suggestive of pumice. It is analogous to the "sugar quartz" occurring in vugs, with sericite, in some of the gold-quartz veins of California, although not to the "sugar quartz" which results from a crushing of the vein.

The National Belle mine has long been noted for the abundance and purity of the kaolin found in its workings.[1] It occurs as a soft, white filling of fractures in the altered country rock, or in brecciated zones as a matrix inclosing fragments of the wall rock. It appeared to be, in part at least, of more recent origin than the sulphide ores, but no opportunity was available to study its occurrence in the deeper workings or in connection with the unoxidized ores. When dry this kaolin forms a pure white powder which the microscope shows to consist of crystal scales, usually hexagonal in outline and about 0.1 mm. in average diameter. The optical properties of these crystals have been described by Reusch.[2] Two chemical analyses of this material are here reproduced, (I) by Hillebrand[3] and (II) by Hiortdahl:[4]

Analyses of kaolinite from National Belle mine.

Constituent.	I.	II.
SiO_2	46.35	45.57
Al_2O_3	39.59	41.52
Fe_2O_3	.11	....
H_2O	13.93	13.58
F	.15	....
	100.13	100.67
Less O for F	.06	
	100.07	

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[1] R. C. Hills: Am. Jour. Sci., 3d series, Vol. XXVII, 1884, p. 472.

[2] Neues Jahrb. für Min., etc., 1887, Vol. II, pp. 70-72.

[3] Bull. U. S. Geol. Survey No. 20, 1885, p. 98.

[4] Neues Jahrb. für Min., 1887, Vol. II, p. 70.

As shown by E. B. Hurlbut,[1] however, not all of the white crystalline powder found in the National Belle is kaolin, but alunite also occurs in nearly identical form, clearly associated with enargite. Hurlbut's analysis is here quoted:

Analysis of alunite from National Belle mine.

Constituent.	Per cent.	Constituent.	Per cent.
SO_3	38.93	H_2O	13.35
Al_2O_3	39.03	Insol	.50
K_2O	4.26		100.48
Na_2O	4.41		

No study could be made in 1899 of the occurrence of the unoxidized ore, chiefly enargite, of the deeper workings of the mine. Some of the enargite occurred lining caves below the zone of oxidation, forming beautiful radiating clusters of orthorhombic prisms several centimeters in length. These prisms are usually covered with a thin moss-like film of malachite and often partly incrusted with minute crystals of quartz.

From reports made to the company by the superintendent, Mr. James K. Harvey, for the years 1891–1896, the ore appears to have occurred in large masses irregularly distributed in the altered country rock and irregular in shape. The greatest recorded length of one of these bodies is about 75 feet, and they commonly varied in width from 1 to 4 feet, although occasionally as much as 60 feet wide. The greatest dimension was commonly nearly vertical, and in some cases the chimney-like form was pronounced (see fig. 20). The unoxidized ore was in part enargite, carrying at its best as much as 30 ounces of silver and 40 per cent of copper. It was associated with both copper and iron pyrites, some tetrahedrite, and galena in diminishing amount down nearly to the No. 4 level. The latter, at the second level, occurred as streaks in the copper and iron pyrites, and carried up to 44 ounces of silver and 60 per cent of lead in 10-ton carload lots. In a winze 50 feet below the third level galena occurred in small nodules only. In the National Belle ore the gold rarely amounted to more than a tenth of an ounce per ton, and was usually much less.

Practically no paying ore was found below the third level, explorations on the fourth level resulting only in finding small bunches of ore and masses of crumbling iron pyrite carrying less than one-tenth ounce of gold and about 5 ounces of silver per ton, with from 1 to 3 per cent of copper. The large north ore body, which on level 3 was a nearly solid mass of ore 31 feet long and 24 feet wide, carrying as a whole 4 to 7 ounces of silver, 4 to 6 per cent of copper, and .04 ounce of gold, and which had been stoped up over 100 feet above level 2, was not encountered in the bottom level. On level 2 this ore body was 75 feet long by 60 feet wide, and carried from 7 to 25 ounces of silver per ton and from 7 to 20 per cent of copper. It is said to have been chiefly iron, pyrite, and chalcopyrite, with some galena and enargite. This ore was firmer and of higher grade than that at the level below. From the annual reports of the company it appears that masses of iron pyrite were not limited to the deeper workings, but occurred above the second level, sometimes immediately beneath the carbonate ore. Much of the higher-grade ore, such as enargite, galena, and tetrahedrite, occurred as bunches of various sizes in the pyrite.

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[1] Am. Jour. Sci., 3d series, Vol. XLVIII, 1894, pp. 130, 131.

Owing to the decline of silver to almost half its former value, the general low grade of the National Belle ore, and the lack of facilities for its economic treatment, it was found impossible to operate at a profit, and the mine was closed in 1897. The ground below the fourth level is as yet unexplored, but the diminished value and amount of ore at that level deterred the company from further sinking.

The water in the National Belle mine was apparently not abundant or troublesome, as no mention is made of it in the superintendent's reports. From the location of the mine and its moderate depth (490 feet) no great amount would be expected.

White Cloud mine.—This mine, now abandoned, lies less than a quarter of a mile north of the Guston. It appears never to have struck a paying ore body. The shaft is sunk on the northern end of an elliptical knob of bleached and silicified San Juan breccia. The length of this knoll is about 50 feet and its trend about N. 10° E. It terminates rather abruptly, with no sign on the surface of any vein in the line of its major axis. The silicified material of the knob is impregnated with small crystals of iron pyrite.

Paymaster mine.—This also is an abandoned property lying a quarter of a mile northeast of the White Cloud. About 16 carloads of ore are said to have been shipped from one ore body, but the mine was never a large producer. It is credited with an output of $14,434 in 1890. In 1899 the shaft was filled with water to within about 200 feet from the surface, and the first level only was accessible. The country rock at this depth is all much altered and irregularly fissured and the fissures are frequently filled with seams of kaolin or talc, which is evidently a product of the alteration of the adjacent rock. Drifts and crosscuts run in all directions from the shaft, but apparently no ore was found on this level. The ore seen on the dump and in the ore bins was essentially a galena ore, associated with much pyrite.

Silver Bell mine.—Lying about a quarter of a mile north of the Paymaster, this, at one time one of the better-known and productive mines of the district, is also dismantled and inaccessible. The shaft, about 700 feet in depth, is now filled with water to within 100 or 200 feet from the surface. Sections through the mine are shown in fig. 21. According to Schwarz[1] this mine had, in 1888, produced large amounts of ore carrying from 500 to 1,000 ounces of silver per ton. This rich ore is said to have been bismuthiferous. The product for the three years that have been recorded in the Mint reports is as follows, the silver being quoted at coinage value and lead or copper not given:

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[1] Proc. Colo. Sci. Soc., Vol. III, 1888, p. 84.

Product of Silver Bell mine.

Year.	Gold.	Silver.	Total.
1887	$2,400	$77,600	$80,000
1888		72,404	72,404
1890	1,512	24,211	25,723

A specimen of the rich ore, obtained from a miner who had worked in the mine, proved on chemical examination to be an argentiferous lead sulphobismuthite. Kobellite, a sulphobismuthite of lead, in which part of the bismuth is replaced by antimony, has been described by H. F. Keller[1] from this mine, associated with chalcopyrite and barite. He gives four analyses, of which the mean is here quoted:

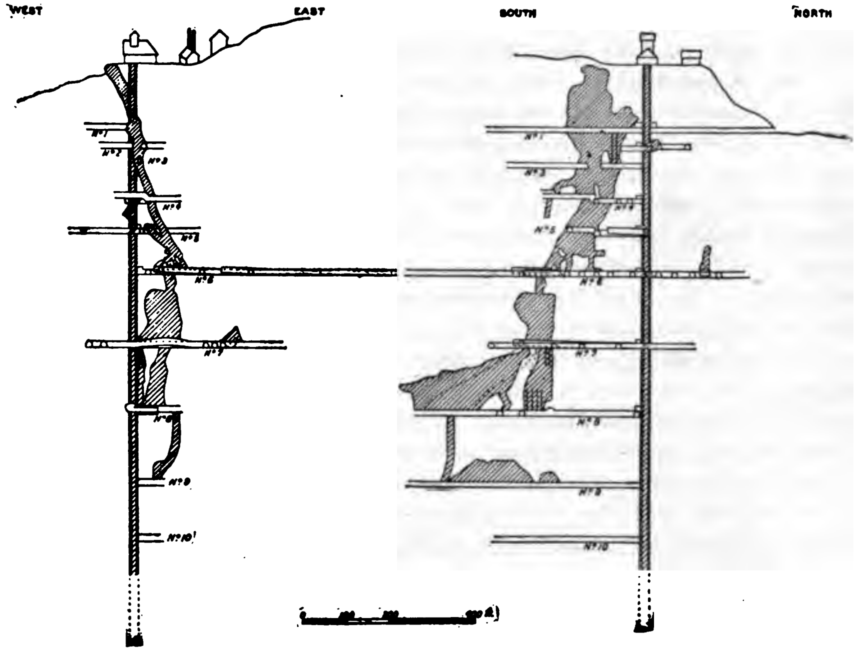

FIG. 21.—Sections through the Silver Bell mine, showing ore bodies stoped.

Mean analysis of kobellite from Silver Bell mine.

Constituent.	Per cent.	Constituent.	Per cent.
S	18.39	Fe	1.50
Bi	28.40	Zn	.39
Sb	7.55	Gangue	.45
Pb	36.16		98.74
Ag	3.31		
Cu	2.59		

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[1] Zeitschrift für Kryt., Vol. XVII, 1890, pp. 67-72.

In 1890 the Silver Bell, with other mines, came into the possession of the American Belle Mines, Limited, of London, and in 1891 the mine was worked through a vertical shaft 706 feet in depth, with ten levels. At this depth about 65 gallons per minute of strongly corrosive water had to be removed by the pumps. According to Superintendent Harvey, this water was "strongly impregnated with sulphuric acid generated from the pyrites in the ore bodies."

The rich ore found in the upper levels changed in depth to large bodies of low-grade ore consisting chiefly of pyrite and carrying less than 20 ounces of silver. Most of the high-grade ore seems to have been extracted when the mine came into the possession of its new owners, and after some attempt to work the low-grade ores in the face of the falling price of silver the mine was abandoned in 1894. Details of the character of the ore and its changes are lacking, but the ore bodies seem to have been generally similar, in shape and in their relation to the country rock, to those of the Yankee Girl.

Congress mine.—This ore body, situated about a mile south of Red Mountain, was located in the autumn of 1881, and sold the following year for $21,000. In 1883, according to the Mint reports, the mine produced about 2,500 tons of ore, valued at $220,000. It was worked through an adit tunnel and a shaft 350 feet in depth sunk from the tunnel. In 1899, after some years of inactivity, the mine was being reopened. The shaft was carried to the surface and new buildings and hoisting plant were in course of erection.

The old workings were not accessible in 1899, but the ore bodies appeared to constitute a chimney-like stock deposit of the kind characteristic of the Red Mountain mines. The ore occurs in irregular bunches, although there is said to be some indication of a vein running nearly north and south. The richest ore was found in a soft, decomposed streak near the surface and carried from $12 to $20 in gold. The ore is chiefly enargite, but there are also bunches of galena, which are said to occur on the peripheries of the ore bodies. The enargite as seen near the surface had been partly brecciated and recemented by a very compact, soft aggregate apparently largely composed of kaolin. In 1900 the mine was again idle.

St. Paul mine.—This property, lying a short distance south of the Congress, shows certain points of resemblance to the latter. Some ore was formerly extracted from a shaft 75 feet deep. The present workings comprise a vertical shaft 200 feet deep, with some drifts at the 200-foot level. The ore is low grade and consists chiefly of enargite with some galena, forming a fine-grained aggregate. It occurs in irregular bunches in much altered andesitic breccia of the Silverton series, which, near the ore, is heavily impregnated with fine iron pyrite, associated with small knots and veinlets of kaolin. No definite line can be drawn between ore and country rock, the former being largely a replacement of the latter. The ore bodies are found by following small seams of gouge or kaolin in the country rock. There is no regular direction to these seams, and they are themselves curved and irregular. The mine has not produced much, but was shipping ore in 1900.

Carbonate King mine.—This property, in Corkscrew or Humboldt Gulch, is opened by a shaft 395 feet deep. After lying idle for some years, work was resumed in 1900. In some ways this deposit is a connecting link between the stock or chimney deposits of Red Mountain and the lodes of the rest of the quadrangle. It resembles in this regard the Henrietta mine, which is described on another page. The ore of the Carbonate King occurs in a distinct fissure, striking about N. 5° W. and dipping west about 50°. The lode is a zone, 4 to 5 feet wide, of crushed country rock, apparently altered andesite, in which the ore occurs in bunches. There is usually a soft gouge on the foot wall of this crushed zone. The ore is sometimes frozen to the hanging wall, sometimes separated by gouge. Between the walls is much kaolin, occurring in the interstices between fragments of altered unmineralized rock. It also occurs as seams in the wall rock.

There is a second fissure of similar character which branches off from the main lode. It strikes N. 20° W. and dips southwest at 60° to 65°. It consists of a zone of crushed rock 4 to 5 feet wide, containing abundant kaolin, and separated by gouge from uneven walls. This branch fissure contains bunches of galena ore.

The ore of the main lode is an intimate mixture of pyrite, one of more sulphobismuthites, and probably tetrahedrite, with barite as the common gangue. No vein quartz was seen. The ore streak may vary from a few inches to 3 feet in width. It is often absent altogether.

The bismuthiferous varieties carry as much as 500 ounces of silver, with lead and copper. Ore worth less than $20 per ton can not be shipped.

Midnight mine.—This mine, situated in Corkscrew Gulch, a short distance below the Carbonate King, has not been worked for some years. It contained some good ore, but its extraction was rendered expensive by the abundant water met with. It is wholly inaccessible at present.

Other mines.—Many other mines, such as the Senate, Hudson, Charter Oak, and Humboldt, were all formerly active in this region, and have in some cases produced considerable ore. In those named the ore, when it occurred, appears to have had the form and characteristics already described as common to the typical Red Mountain deposits. All these mines had been abandoned in 1899 and consequently were not accessible for study, and very little information regarding them could be obtained. The Hudson, owned by the American Belle Company, was worked through a vertical shaft 253 feet in depth. The ore does not appear to have occurred in large bodies. On the first level ore consisting of pyrite and chalcopyrite (and probably enargite) carried from 20 to 26 ounces of silver per ton and 6 to 40 per cent of copper. The mine was closed in 1891. In 1895, 20 tons of enargite ore, carrying about 20 per cent of copper, were collected from the dump and realized $18.77 per ton. In its general character the ore of this mine seems to have been very similar to the low-grade ore of the National Belle, carrying enargite and copper and iron pyrite.

Other mines and prospects, showing more or less ore occurring in typical Red Mountain form, occur at the heads of Prospect and Dry gulches on the eastern slope of Red Mountain. The Mineral King, in Prospect Gulch, has a shaft 150 feet deep, sunk to develop a "chimney" of ore which outcropped in the bed of the creek. This ore shoot was cylindrical in form and nearly vertical, with a diameter of about 6 feet. The ore was a highly argentiferous copper ore, which is said to have contained as much as 1,300 ounces of silver per ton. It was surrounded by the usual envelope of silicified andesitic breccia, which graded outward into less altered forms of the same rock. This ore body pitched slightly to the south, and was followed down for 110 feet, when it pinched out. Forty feet deeper, drifts have been run in all directions in an endeavor to find a continuation of the pay shoot, but without avail. The rock at this level is traversed by numerous fissures, usually carrying some kaolin and accompanied by kaolinization of the wall rock. They sometimes widen into "pockets" filled with soft, unctuous yellow clay. One prominent fissure has a course of N. 80° W., another of S. 5° W., and still others run in various directions. It is probable that the original ore channel was formed by the intersection of two or more of these fissures. All of the andesitic breccia exposed in the artificial openings of this vicinity show some mineralization, with frequent small bunches of galena and other ore, but it was apparently only under exceptionally favorable conditions of fissuring that this diffuse mineralization was concentrated into ore bodies of workable size.

Near the head of Prospect Gulch the Galena Queen, with a shaft about 300 feet deep, shows a dump of similar character to that of the St. Paul. It is no longer worked.

Active prospecting was in progress in 1900 in the neighborhood of the Galena Queen, many of the shallow openings showing some ore.

The Henrietta mine, in the lower part of the same gulch, is described with the Cement Creek mines, on page 257.

The Webster, at the head of Dry Gulch, is worked through an inclined shaft 320 feet deep. The shaft is sunk on a fissure carrying a little gouge, in Silverton breccia. This fracture strikes about S. 10° W. The dip at first is about 75° to the south, but at 200 feet it flattens to about 45°. A little argentiferous copper ore has been found in bunches.

Saratoga mine.—On the eastern side of Ironton Park are several ore deposits which are of different types from those just described. The conspicuous alteration which has given the rocks of Red Mountain their brilliant tints is limited on the northeast by Grey Copper Gulch, and it is to this area of altered rock that the peculiar chimney-like deposits of the Yankee Girl type are confined.

The Saratoga was located in 1883, and has produced in all about $125,000. A far greater sum than this has been expended in development and in the erection of an expensive lixiviation plant. Considerable work was done in 1886, and in 1889 and 1890 about 100 men were employed. Since 1890 work has been confined to extracting pockets of ore with two or three men.

The lowest formation exposed at the Saratoga mine is a massive quartzite, white or light buff in color, which outcrops near the mill, with no recognizable bedding. Without much doubt this quartzite represents a portion of the Algonkian series, here rising a little above the level of Ironton Park. Lying unconformably upon this quartzite is a locally nearly horizontal formation of limestone, sometimes thinly bedded, which is probably of Devonian age and to be correlated with the limestone occurring south of Silverton. The thickness of this limestone is not known, but is apparently somewhat variable, and in places it certainly reaches a thickness of 75 feet.[1] Some thinly bedded portions at its top appear to have been silicified, forming a material resembling quartzite at first glance, but composed of vein quartz containing numerous little vugs. Above the limestone there occurs a thin stratum of telluride conglomerate, originally composed largely of limestone pebbles, but now silicified and with its conglomeratic character obscured. This appears to represent the rapidly thinning eastern margin of this conglomerate, for it is not recognizable a short distance within the hill, in the mine workings, where the volcanic breccias of the Silverton series, containing some massive andesite, lie upon the limestone.

The ore body of the Saratoga occurs in the limestone, and probably in part in the telluride conglomerate, and is very irregular. Near the surface of the hill it is a mass of soft, rust-colored, oxidized material, easily worked with pick and shovel, and traversed by numerous irregular seams of soft clay gouge. The pay ore occurs along these seams or gouges and is chiefly a carbonate of lead carrying silver, probably as chloride. Residual kernels and masses of white crystalline limestone are of frequent occurrence, surrounded by the rusty decomposed material of the ore body. The best ore is found resting on the oxidized upper surface of a mass of iron pyrite. This pyrite varies greatly in thickness, and in what is known as the lower tunnel it is nearly 100 feet thick—a mass of nearly pure, crumbling pyrite, resting on the quartzite, or occasionally on limestone, when the latter has not been wholly replaced. This pyrite carries, according to Mr. W. R. Fry, part owner and former superintendent of the mine, from 3 to 4 ounces of silver and 0.4 to 0.5 of an ounce of gold, being thus too poor to work. Several tunnels have been run into the hill, but owing to the easterly dip of the ore they all pass through the ore body and, if continued far enough, come into the volcanic rocks of the Silverton series. This oxidized ore is not capped by the overlying andesite, but passes upward into the loose material and soil of the present surface of the hillside. When, however, the ore is followed far enough to the eastward it passes beneath andesitic breccia and changes to a sulphide ore, consisting of pyrite and a little chalcopyrite, with occasional bunches of partly oxidized pay ore, carrying galena and argentite. This ore is the result of a replacement of the limestone to varying depth along the contact between it and the overlying andesitic breccia. It varies in thickness from a few inches up to 3 feet. The overlying volcanic breccia is usually much altered, thickly impregnated with pyrite, and traversed by veinlets of the same mineral. The ore is not distributed at random through the contact plane between limestone and breccia, but the bunches of ore thus far found lie along a line bearing about N. 30° E., as if the mineralization had been controlled by some fissure or fissures having this direction. As this is the dominant direction of fissuring in the vicinity, this seems not unlikely. The actual fissure which determined the mineralization is, however, not readily identified. It may lie to the westward, in which case its intersection with the ore horizon has been removed by erosion. It may be the large lode, presently to be described, which lies to the eastward, or it may be some less conspicuous fissure. A small fissure having this strike of N. 30° E. was

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[1] According to Kedzie, loc. cit., its mean thickness is 140 feet.

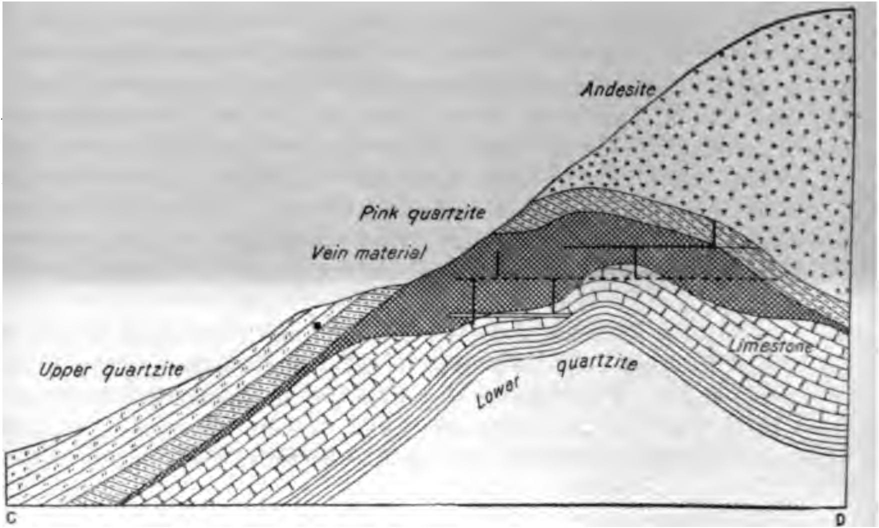

FIG. 22.—East-and-west section through the Saratoga mine. (After G. E. Kedzie.)

noted, which faulted the ore body, throwing down the southeast portion a few inches. This, however, appeared to be a post-mineral fault and is probably a late manifestation of the same faces which produced the earlier dominant fissuring of identical trend.

The upper tunnel of the Saratoga has been run 1,000 feet into the hill. It passes through the ore and limestone into a fine-grained, massive andesite, and about 600 feet from its mouth cuts a strong lode carrying pyrite, in a gangue of vuggy, white quartz. This vein is from 2 to 3 feet wide, striking N. 30° E., and dipping southeast at about 85°. It is too low grade to work. Beyond the lode the tunnel passes through about 50 feet of iron pyrite, limestone, and quartz—all much shattered. This appears to be a mineralized fault breccia, disturbed by later movement. On the southeast of this shattered zone is andesitic breccia, but owing to the gas in the end of the tunnel it was found impossible in 1899 or 1900 to make any further observations.

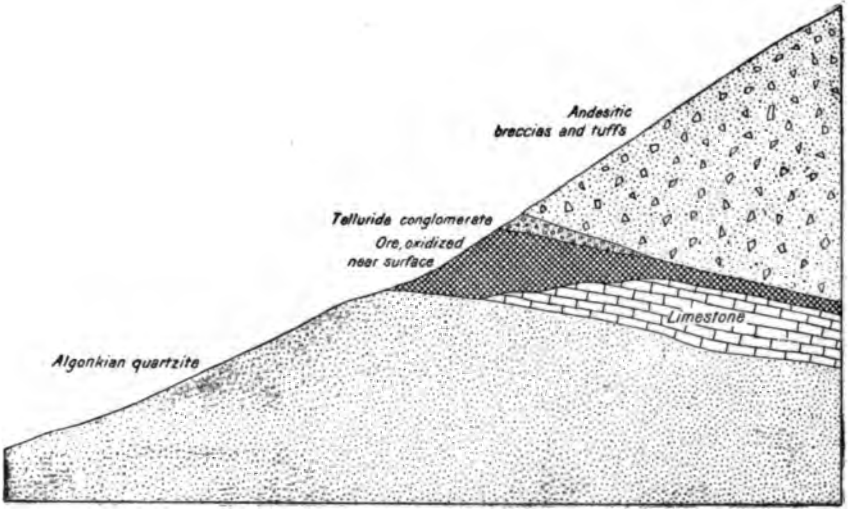

FIG. 23.—Diagrammatic east-and-west section, illustrating in a general way the occurrence of ore in the Saratoga mine.

It is to be noted that G. E. Kedzie[1] has interpreted the form of the Saratoga ore body in a different manner from that set forth in the foregoing pages. His section is herewith reproduced (fig. 22). This same section is also given in Phillips and Louis's Treatise on Ore Deposits, although these authors remark that there seems to have been hardly enough work done to pronounce very positively as to the character of the ore body.[2] At the time of Kedzie's visit the mine was more accessible throughout, but not enough ground had been exploited upon which to base all the details of his section. Thus his "upper quartzite" appears to be the same as the massive quartzite here included in the Algonkian. His "pink quartzite" is evidently the silicified telluride conglomerate, while his "lower quartzite" could not be identified in the Saratoga workings. He states that it is penetrated by the Jackson tunnel, about 800 feet southwest of the Saratoga, but this tunnel is no longer accessible. A truer representation of the ore body and its relations to the inclosing rocks is believed to be afforded by the rough diagram, fig. 23.

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[1] The bedded ore deposits of Red Mountain mining district, Ouray County, Colo.: Trans. Am. Inst. Min. Eng., Vol. XVI, 1887-88, pp. 570-581.

[2] A Treatise on Ore Deposits, J. Arthur Phillips, second ed, rewritten and enlarged by Henry Louis. London, 1896, p. 163.

In 1900 a drift was being run along the ore-bearing horizon toward the northeast with the object of ascertaining whether any ore has been deposited at the intersection of this horizon by the large vein cut in the tunnel above. This seems an advisable piece of prospecting. Hitherto the development has been rather unsystematic, and it was not discovered until 1900 that the large oxidized ore bodies were continuous, with sulphide ores passing beneath the andesitic breccias to the eastward.

Baltic group.—This group, comprising the Maud S., Mono, and other claims, is a prospect in Brooklyn Gulch, south of the Saratoga. The principal work at present is in connection with the Mono lode, which strikes N. 43° E. and dips northeast at about 75°, and is reached by a tunnel through the limestone about 400 feet in length. This lode occupies a fault fissure of at least 100 feet throw, which drops the overlying andesitic breccia on the southeast until it lies against the limestone. The ore, consisting of nearly solid pyrite and chalcopyrite, occurs as a vein in the fault fissure and as a relatively flat replacement deposit between the limestone and overlying andesite on the northwest side of the fault. Where both walls of the fissure are andesitic the vein is narrow; but where one wall is limestone it widens, evidently by replacement of the calcareous wall. There has been some post-mineral movement along the fault fissure, as shown by the presence of gouge and slickensides.

The ore is low grade, carrying at its best about 30 ounces of silver and 12 per cent of copper. Ore of this general character is very abundant both here and in the Saratoga mine, but can not at present be economically worked.

It is evident that the ore bodies have been only partly prospected. No attempt has been made to find the ore which very likely exists at the top of the limestone on the downthrown side of the fault. This would seem to be an excellent opportunity to employ a diamond drill, provided the known ore bodies indicate that the ore on the other side of the fissure is worth searching for.

The Maud S. is also on a fault fissure, which crosses the gulch near the mouth of the Mono tunnel. Its general strike is N. 30°–40° E., and its dip southeast at about 85°. This also is a normal fault, letting down the andesite against the limestone on the southeast for at least 25 feet. Some argentiferous copper ore was formerly taken from this claim, the ore occurring in replacement bunches in the limestone alongside the fault. The ore is associated with a soft, black alteration product or residue of the limestone. Between the Maud S. and the Mono fissures is a third fault exposed on the Mono tunnel, of variable northeasterly strike, dipping southeast at about 70°. Here also the andesitic tuff or breccia is brought down on the southeast so as to be in juxtaposition with the limestone. The fault is well shown in a long drift run on it to the southwest. The fissure contains soft gouge and shows slickensides, but is about destitute of ore.

The Brooklyn tunnel, 200 feet below the Mono tunnel, enters in limestone, which is probably over 200 feet thick in this gulch. The tunnel has several branches, the longest about 800 feet in length. It cuts through at least two large masses of crumbling iron pyrite, formed by replacement of the limestone. These masses are bounded on the southeast by a northeast fault plane, which brings them against a downthrown mass of andesitic breccia. This fault is supposed to be the one already described between the Maud S. and Mono fissures. The only one of these pyrite masses which could be reached in 1900 is at least 6 feet in thickness (the height of the drift), and probably considerably more. Northwest of the fault it extends irregularly into the limestone for over 100 feet. Northwest of these masses of pyrite is a long northeast drift, which appears to follow a fault for most of its course. On the southeast side of the drift is limestone with bunches of iron pyrite. On the northwest side is an irregularly laminated and much disturbed quartzite, which may probably be the "lower quartzite" of Kedzie. The general strike of this laminated quartzite, i. e., of the laminæ, is about northeast. The general dip is northwest, but exceedingly variable. This quartzite belongs presumably below the limestone, but whether it is the same as the massive quartzite at the Saratoga Mill or is a younger quartzite not there seen, and perhaps of Devonian or Silurian age, is not at present known.

Jay Eye See mine.—This also is a prospect situated in Parole Gulch, south of the Maud S. A shaft was formerly sunk on a heavy lode or bunch of pyrite, associated in this case with a little quartz gangue. No pay ore was ever found in this shaft. Subsequently a tunnel run in just west of the shaft cut a lode which in places carried tetrahedrite, pyrite, and chalcopyrite up to 4 feet in width. The ore occurred in lenses connected by a barren seam of clay gouge in soft decomposed andesitic tuff-breccia, and the mine never paid steadily. The tetrahedrite sometimes carried 400 ounces of silver per ton. The bodies of pyrite cut in the original shaft are quite probably part of the Mono lode. But parallel fault fissures of southeasterly dip and normal heave are here so common, however, that identification of any single one is almost impossible.

Barstow mine.—This mine, formerly known as the Bobtail, was the only mine in the Red Mountain district working and producing ore in 1899 and 1900 on any considerable scale. It is situated about a mile west of the Guston, on a prominent lode running up Commodore Gulch, on which the Iranstan, Bobtail, Hector, Saratoga, and Moscow claims are located. The Iranstan and Bobtail were worked early in the eighties, but have been idle for the last few years, until work was resumed by the Barstow Mining and Milling Company. The mine is opened by an oblique crosscut tunnel and all the work is on one level.

The lode, which has a general northwest-and-southeast strike, and dips southwest at about 50°, is a large one, 30 to 40 feet wide, but the ore is confined to one or two rich streaks in its middle portion. The lode contains much soft, altered country rock and is traversed by clay gouges, making it exceedingly treacherous and difficult to work by overhand stoping. The mass of the lode contains pyrite, chalcopyrite, sphalerite, and some bunches of low-grade galena. The gangue is chiefly quartz, often cavernous and drusy, with a little fluorite. The best ore is a light-gray metallic mineral called "gray copper" at the mine, which, when pure, assays as much as 2,000 ounces of silver and 25 ounces of gold per ton. The gold always accompanies and is proportional in amount to the silver. Chemical examination shows that the so-called "gray copper" is in this case an argentiferous lead sulphobismuthite containing almost no copper, probably the mineral cosalite. But the present material obtainable (sp. gr. 7.04 at 30° C.) proves on chemical investigation to be a mixture of the lead sulphobismuthite with pyrite and some telluride. Under these circumstances it was inadvisable to spend time in making a complete quantitative analysis. From his preliminary tests, however, Dr. W. F. Hillebrand has kindly supplied the following rough approximation to the composition of the mixture:

Approximate composition of mixture from Barstow mine.

Constituent.	Per cent.	Constituent.	Per cent.
Pb	45.5	Cu	.3
Bi	22.5	Fe	3.5
Ag	6.0	S	14.1
Au	.06	Insol	1.5-2.0

The lead of cosalite is known to be sometimes partly replaced by silver and copper. In this particular case the silver is evidently accompanied by some gold, which is probably combined with tellurium and not directly with the sulphur and bismuth. The sulphobismuthite is often closely associated with chalcopyrite, which carries little value. The rich ore streaks are more or less lenticular in form and are usually separated from the mass of the lode by wet clay gouges. The best ore occurs nearer the footwall. As the workings are confined within the mass of the lode, the relation of the latter to the wall rock could not be studied.

Silver Ledge mine.—This property, situated about half a mile north of Chattanooga, and operated by the Ledge Mining and Milling Company, is worked through a shaft about 400 feet in depth, sunk in the bed of Mineral Creek. Most of the work at present is on the fourth level, at a depth of 360 feet, and in the stopes immediately above it. The workings are all in rhyolite. This rhyolite forms a considerable area extending to the westward of the mine with a rather irregular boundary. Its eastern limit is very close to the mine workings. For more detailed accounts of this rhyolite mass the reader is referred to the forthcoming work of Mr. Cross. The conclusion reached by him at the present writing is that it represents an area of the Potosi rhyolite[1] which has been faulted down into the surrounding rocks. If this view is correct the rhyolite is limited in depth. There are no data now available for even a rough estimate of the thickness of this rhyolitic mass, but if mining be pushed deep enough it will be passed through. If, on the other hand, the rock is intrusive, it may extend to practically unlimited depth.

There are certain features about the rock itself which sustain Mr. Cross's hypothesis. It has many of the characteristics of the surficial rhyolite flows of the Potosi series, and, as far as could be seen in its altered condition near the mine, has not the crystalline structure that might naturally be looked for in an intrusive mass of such size. Moreover, on the 400 level of the Silver Ledge occur masses of a compact, slightly pinkish rock, which are sometimes fairly distinct from the white altered rhyolite and sometimes appear to grade into it. This pinkish rock occurs as isolated patches or nodules in the rhyolite, and at one point forms a considerable mass, of which the bottom is not yet exposed. Under the microscope this rock shows numerous small grains of quartz in a very minutely crystalline sericitic groundmass. It is, without very much doubt, a devitrified glassy rhyolite or rhyolitic tuff. Such material could hardly occur in such a place if the rhyolite were intruded. It strongly suggests volcanic or effusive conditions. It is even possible that the appearance of this material indicates an approach to the bottom of the rhyolitic mass.

The work of Mr. Cross has established the existence along the eastern border of the rhyolite mass of a fault which, just southeast of the mill, brings the rhyolite against andesite on the east. The line of this fault would carry it not far east of the main shaft, and it was thought that a crosscut which had been driven 100 feet to the eastward from the 400 (360 feet) level might be found passing through this fault fissure into andesite. About 70 feet east of the shaft the crosscut does pass through a strong gouge-filled fissure, but the rock, although all much altered, shows no change either in hand specimens or under the microscope. It all appears to have been originally rhyolite.

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[1] See the Telluride folio, No. 57.

The ore, consisting of galena and sphalerite, occurs replacing and impregnating the rhyolite in the vicinity of two or more fractures, which have a general strike of about N. 27° E. and dip southeast at a high angle. These fissures contain crushed country rock and ore, and there has evidently been late movement along them since the ore was deposited. They are probably merely a portion of a pronounced fault zone, which here follows the general trend of the creek. The ore bodies are found by following these fractures, but are not confined within their walls. They extend irregularly into the rhyolite for 30 or 40 feet to the west, the low-grade galena, associated with considerable sphalerite, sometimes forming large masses wholly replacing the rhyolite, but more often impregnating it thickly in small nests and isolated particles. There are no walls to the ore bodies, and they are followed into the rhyolite until the proportion of ore to gangue becomes too small for profitable working. Very little ore has thus far been found to the east of the fissures, although the workings have as yet revealed no change of country rock in that direction.

The rhyolite has been altered in connection with the ore deposition to a finely crystalline mass of sericite, kaolin, and quartz in varying proportions, serving as gangue for the ore.

The principal fractures of this mine appear to be comparable to the so-called ore break in the Guston mine. It is very probable that the zone of fractures extending up Mineral Creek and passing just east of Summit forms part of the fissuring found in the Lake and National Belle mines near Red Mountain.

The ore of the Silver Ledge is concentrated in a small mill run by steam. It is equipped with 1 Gates crusher, 2 sets of wells, 4 three-compartment jigs, 10 stamps, and 4 double-deck and 2 single-deck Wilfley tables. The capacity is about 60 tons a day. The principal output of the mine is a low-grade galena, which is shipped in the form of concentrates. A little free gold, associated with a telluride supposed to be calaverite, was found on the 300 level as a thin skin on a slickensided fracture surface in the usual impregnated rhyolitic country rock. This was the only occurrence of free gold known in the mine.

The future development of this mine is likely to be of great interest. It is evident that if the interpretation of the rhyolite as a down-faulted sheet or flow be correct, then an entirely different set of conditions will be encountered when the bottom of the rhyolite is reached. In all probability the ore deposit will become a simple fissure vein or a series of parallel veins. Moreover, further exploration of the country east of the shaft may reveal ore bodies yet unknown. The crosscut already begun in this direction might perhaps be extended with advantage until the andesitic rock of the Silverton series is reached.

Magnet mine.—This, an old location, is situated on the east side of Mineral Creek, near Burro Bridge. It produced a little rich silver ore in the early eighties, but owes its interest at present to the occurrence of a telluride of silver, probably hessite.

The workings comprise a tunnel about 540 feet in length and a few superficial openings. The lode strikes N. 85° W. and dips from 60° to 80° to the south. It is a compact stringer lode, in places 2 feet wide, which contains considerable mineralized and altered andesitic breccia, which forms the country rock. The stringers are filled with quartz, "frozen" to the walls and containing bunches of ore. A radial structure of the quartz is common and vugs are numerous. The ore, consisting of argentiferous galena, a silver telluride (hessite?), a little free gold, sphalerite, chalcopyrite, and pyrite, occurs partly in the quartz and partly replacing the included fragments of breccia. The richest ore, containing the hessite, is usually associated with the radial quartz and often occurs in the interstices between the outer ends of the crystals. The ore is unevenly distributed through the lode and has been found only in small bunches.

Brobdignag claim.—This abandoned prospect is of interest as the locality whence some zinkenite was formerly obtained, which was described and analyzed by Dr. Hillebrand.[1] No ore was visible in 1900. The country rock was apparently originally an andesite, but is altered to a white aggregate consisting chiefly of quartz and barite.

Zuñi mine.—This mine, well known in mineralogical literature as the source of guitermanite and zunyite, is situated near the summit of Anvil Mountain, at an elevation of about 12,000 feet. The ore body was worked from the surface by an open cut and a shaft and by two tunnels. The upper tunnel branches, the two breasts being 156 and 180 feet in from the surface. A second tunnel, 200 feet below the upper one, is 540 feet in length. There is no connection between these two tunnels.

The surface ore of the Zuñi, discovered in 1881, was chiefly massive sulphate of lead (anglesite) containing abundant small tetrahedral crystals of unaltered zunyite. This soon changed to unoxidized guitermanite in characteristic association with zunyite. This was the chief ore of the upper tunnel, and occurred in a mass about 60 feet long and 15 feet wide. Below the tunnel level this bismuthiferous lead ore decreased in width to about 6 feet and changed gradually to a copper ore, consisting chiefly of enargite, with pyrite, kaolin, and a little barite. The enargite carried about 216 ounces of silver and 40 per cent of copper. In the lower tunnel the ore body, about 40 feet long and 12 feet wide, is a soft mass of kaolin and embedded pyrite, with nests of enargite. The pyrite occurs chiefly in octahedra and is said to carry a very little gold. The ore at this depth contains many fragments of the immediate country rock, a much altered porphyry, apparently originally an andesite or latite. The contact between the ore and these fragments is perfectly sharp, and the latter often have sharp, angular corners.

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[1] Bull. U. S. Geol. Survey No. 20, p. 93.

Small masses of similar ore, showing no apparent connection with the main body, were encountered at several points in the tunnel. They often contain small caves or vugs lined with crystals of quartz, barite, enargite, and pyrite. The country rock around such caves is brecciated and the crevices are filled with ore. The ore in the lower tunnel, consisting chiefly of pyrite, is too low to work. The longer diameter of the Zuñi ore body apparently strikes about N. 15° W., and the dip is from 75° to 80° to the west.

There are several smaller prospects of the general type of the Zuñi on Anvil Mountain. These are usually small irregular bunches or "chimneys" of ore of small horizontal and vertical extent. They sometimes occur immediately at the surface, as in a claim owned by John Roland, where masses of galena, showing only superficial oxidation, occur at the grass roots. In some cases the surface ore is argentiferous enargite (Dewey claim). There can be little doubt that many undiscovered small irregular masses of ore occur within the altered andesites and other igneous rocks of Anvil Mountain. But such is their irregularity in occurrence, and so limited are they in extent, that small inducements are held out for extensive deep prospecting.

Meldrum and Hammond tunnels.—The success of the Revenue tunnel has encouraged the prosecution of other extensive tunneling ventures in the vicinity. The Meldrum tunnel is being driven on a coarse about 4° S. of W. from a point on Red Creek opposite the Silver Bell mine through to Bridal Veil Basin in the Telluride quadrangle, a distance of over 4 miles. The tunnel is 12 by 12 feet and had run about 900 feet in 1899. Work was also in progress at the western end of the tunnel line. In 1900 all work was suspended. The Hammond tunnel also enters from Red Creek, nearly west of the Yankee Girl mine and has a course of N. 80° W. It had a length of about 2,000 feet in September, 1900—all in andesitic breccia. As a rule the rock is solid, very little timbering being required. But in the neighborhood of 1,000 feet from the mouth some zones of recent brecciation, dipping eastward, are cut through. These indicate faulting, possibly connected with the movements of landslide character revealed in the topography above the tunnel.

These tunnels are evidently designed to cut the continuation of the Tomboy lode and other less known and undeveloped lodes traversing the high ridge west of Red Creek. A very large outlay of capital will be required to complete them. Without expressing an opinion upon these particular enterprises, it may be pointed out that, in so far as the projectors of long tunnels count upon finding richer or more abundant ore than is indicated near the surface, they are playing a game of chance in which the probabilities are decidedly against them. But where the object is to cut a lode of proved value and continuity, as was the case with the Virginius lode tapped by the Revenue tunnel, the unertaking involves no more than the legitimate risks incident to most large business enterprises.

MINES OF SULTAN MOUNTAIN.

North Star mine.—Situated on the northern slope of Sultan Mountain, about a mile southwest of Silverton, this mine was at one time one of the largest and most productive in the quadrangle. It was located in 1876, but not extensively worked until about 1881, when it became the most productive mine in San Juan County, some 3,000 tons of ore having been mined. At the close of 1882 the workings comprised about 1,700 feet of drifts, and, according to the report of the Director of the Mint, over 100,000 ounces of silver and 1,500,000 pounds of lead had been extracted. The ore at that time was shipped to St. Louis, and is said to have carried from 70 to 80 ounces of silver and 35 per cent of lead. In 1883 the output is given by the Mint reports as $200,000, and in 1884 as 1,100 tons, value not stated. The same source gives the product for 1888, 1890, and 1891 as $46.522, $206,072, and $337,192, respectively, the silver being reckoned at its coinage value. The mine was finally closed about 1897, it having been practically worked out down to the tunnel level.

The main adit is a tunnel (No. 7) 7 feet in the clear and 2,100 feet in length, which has its entrance about 50 feet above Mineral Creek and penetrates the mountain in a southwesterly direction, cutting the lode nearly at right angles. The latter is a fissure vein in monzonite, striking nearly northwest and southeast, but showing considerable variation in trend. The dip is to the southwest at from 45° to 60°. The monzonite near the vein is decomposed and soft, and when the mine was visited in 1899 it was found impossible, on account of caving, to reach the ends of any of the drifts or to enter the stopes. The vein contains much quartz, and is usually wide, the average width according to one account being about 8 feet. The pay streak, generally about a foot wide, and consisting of galena and tetrahedrite, occurs very persistently along the footwall side of the vein. The pyrite occurring in the more quartzose portion of the vein is said to carry some gold, and small amounts of the latter have been found free. The average tenor of the ore is reported to have been about a half ounce of gold, 40 ounces of silver, and 50 per cent of lead.

About 100 feet southwest of the North Star vein is the Crown Point and Wheal Alfred lode, a nearly parallel quartz vein carrying some gold. The dip of this lode is steeper than that of the North Star. It shows pyrite, chalcopyrite, and tetrahedrite, with a little specularite, in a quartz gangue. Barite is probably present in both lodes.

An abundant flow of water issues from the main tunnel, and proved troublesome when the mine was being worked on account of the rapidity with which it corroded rails and pipes.

The North Star mill, erected about 1890, is equipped with 2 Blake crushers, 3 sets of rolls, 8 three-compartment jigs, 2 four-compartment jigs, 20 stamps, and 3 Woodbury tables. The power is water. This plant was running in 1899 as a custom mill.

Belcher mine.—This mine, now abandoned, is situated in the high basin opening to the northeast on the northeast side of Sultan Mountain, the principal adit being at an elevation of about 11,250 feet. It was located in 1876, yielded over 300 tons of ore in 1881, and in 1882 had become a steady producer. In 1883 there were three levels opened by tunnels, and a product of 1,700 tons of ore is recorded, averaging 38 ounces of silver and 40 per cent of lead. The outputs for the years 1883, 1884, 1890, 1891, and 1892, as given in the Mint reports, were $85,000, $13,500, $8,467, $34,995 and $63,510, respectively. The Belcher lode is in monzonite, and is said to be very similar to the North Star lode and to have nearly the same strike and dip. The workings were wholly inaccessible in 1899, and no observations could be made on the lode itself. According to Mr. W. H. Thomas, at one time part owner of the mine, the galena ore was less abundant in the lower levels, its place being largely taken by sphalerite. According to another former owner, the lode was practically worked out down to the tunnel level, and there is no reason to suppose the good ore to be any less abundant below the bottom workings.

Fragments of ore seen on the dump of the lowest tunnel showed galena, sphalerite, pyrite, chalcopyrite, and tetrahedrite in a gangue of quartz and barite with some calcite. The ore was sorted, sacked, and carried on burros down a steep trail to Silverton.

Empire group.—Through the present Empire tunnel it is intended to work a group of claims on the northeast slope of Sultan Mountain, overlooking Silverton and Bakers Park. The more important of these claims are the Empire, Little Dora, Victoria, Jennie Parker, Ajax, and Hercules. They cover portions of three important lodes, which are only roughly parallel and which have a general trend of about N. 20° W. The Jennie Parker and Hercules are supposed to form a continuation of the North Star lode.

The Empire and Jennie Parker were worked at a very early date by Melville & Summerfield, who in 1876 had a shaft 50 feet deep on the Empire lode and were erecting reduction works near the Animas River. They were apparently not successful, and the mine was idle for some years. In 1882 the Little Dora lode, which in 1881 was shipping ore from a shaft, was struck in an upper tunnel. This is a clean-cut fissure vein, usually about 2 feet wide, and, although small, has produced a fair amount of ore. The Empire at this time was opened by a shaft 125 feet deep and is said to have had about 18 inches of excellent ore, largely tetrahedrite, which averaged 100 ounces of silver and 10 per cent of copper. In 1883 the Ajax and Victoria were being developed by tunnels. None of these lodes has thus far been worked on an extensive scale.

They are all simple, nearly vertical fissure veins in monzonite. The ore is mineralogically similar to that found in the North Star lode, viz, galena, sphalerite, tetrahedrite, chalcopyrite, and pyrite, in a gangue consisting chiefly of quartz with some barite. With the prevailing price of silver, the ore is, as a whole, low grade.

The Empire tunnel enters the mountain about 150 feet above the bed of Mineral Creek, and has a straight course of S. 35° W. It cuts the Little Dora vein about 1,230 feet from the tunnel mouth. About 900 feet farther in it passes through a fissure about 10 feet wide, filled with crushed rock and gouge, but containing no ore. This is probable the Jennie Parker-Hercules lode, which it was expected to cut about 800 feet beyond the Little Dora. The tunnel was 150 feet beyond the large fissure in August, 1900, and still driving on in solid monzonite. An upper tunnel, 208 feet vertically above and about 400 feet west of the Empire tunnel, formerly known as the Montezuma and used to work the little Dora, has been relocated as the Boston tunnel and extended through to the Hercules lode, here found to be a strong vein up to 10 feet wide, dipping to the southeast at about 85°. It showed evidence of post-mineral movement along the fissure, particularly along the foot wall. The Empire-Victoria vein, as drifted on from the Boston tunnel, is fairly regular and shows a width up to 7 feet. Its dip is somewhat variable—in places as low as 65° to the southwest. Hübnerite, associated with fluorite, occurs as crystalline streaks and bunches next the hanging wall, and usually surrounded by soft gouge. It is probably of later formation than the ore.

On account of the very favorable location of the Empire tunnel it is expected that ore considerably below what is commonly regarded as the lowest grade for profitable working in this region can be here successfully handled.

Other mines and prospects.—The Fairview is a prospect a little more than a mile south of Silverton, at the contact between the intrusive monzonite stock of Sultan Mountain and the Algonkian schists and overlying limestone. The property includes a nearly north-and-south vein, carrying ore mineralogically similar to that of the Hercules lode. The Devonian limestone also, near the monzonite, has been mineralized and carries particles of native silver. Argentite is also reported. Two tunnels, one 200 and the other 600 feet in length, have been run, but there is not enough development to allow satisfactory study of the deposit.

The King lode is a quartz vein in Algonkian schists in Cataract Gulch, and outcrops just below the basal conglomerate (Cambrian?) which underlies the Devonian limestone and rests unconformably upon the edges of the schists. The strike of the vein is N. 6° W., and it dips westerly at 78°. It varies in width from 18 inches to 4 feet, and is destitute of gouge. The inclosing schists strike N. 85° E., and their planes of schistosity stand nearly vertical. The vein thus crosses the schistosity nearly at right angles. No offsetting of the schists could be detected on opposite sides of the fissure. The King lode is faulted by a small vein dipping south about 50°, and the northern portion of the lode is thrown about 12 feet to the west.

The ore of the King lode consists of galena, gray copper (probably tennantite), and chalcopyrite, with some sphalerite and pyrite, in a quartz gangue. It carries about 0.1 ounce of gold, 55 ounces of silver, and 15 per cent of lead.

Close to the King lode is a deposit of chalcopyrite, which occurs at the contact between the limestone and the underlying quartzite. This deposit is apparently directly connected with a fissure of rather flat southerly dip, which traverses both quartzite and limestone.

The Moles mine, now abandoned, is on a nearly vertical fissure vein, about 2 feet wide, in limestone, chert, and shales of Devonian age. The vein strikes N. 72° W., and occupies a fault fissure.

MINES OF CEMENT CREEK.

General.—The ore deposits of Cement Creek occur in lodes, which in Ross Basin attain great prominence. The ores are prevailingly low grade, carrying silver and lead, or, as in the case of the Gold King mine, a large proportion of gold. The occurrence of hübnerite, although it is not at present worked on a commercial scale, lends additional interest to the ore deposits of this portion of the quadrangle. A few of the mines within the Cement Creek drainage have been described in connection with adjacent portions of the region, for, as elsewhere pointed out, the geographical grouping of the ore deposits of the quadrangle has no necessary significance beyond convenience of description, and is accordingly not rigidly adhered to when other courses seem desirable.

Gold King mine.—This property, with which are included the Sampson and American mines, now under the same ownership, is by far the most important mine of the Cement Creek district. It lies on the western slope of Bonita Peak, with the present main adit tunnel at about 12,500 feet elevation. Two lodes are worked, termed, respectively, the Davis and Gold King. Both have a general northeast course, and on the main level are about 70 feet apart. The Gold King lode, which is the northwesterly one, dips southeast at about 75° on the main level. The dip of the Davis is to the northwest, but nearly vertical. In the lower level, 107 feet below the adit, these lodes are closer together. Both are strong, typical stringer lodes without any gouge. So little have they been disturbed by post-mineral movements that there is practically no water in the mine. The ore is a network of irregular stringers, inclosing much mineralized andesitic country rock. Distinct walls are lacking, and the ore is taken out to a width determined by its value. This is sometimes over 30 feet.

The Gold King lode is particularly irregular, and its character led almost inevitably to the litigation between the Gold King and Sampson companies, which was wisely settled by the purchase of the latter by the former.

It shows a marked tendency to split, inclosing large, irregular horses of the country rock, and dividing locally into two or more apparently distinct lodes of varying dips and strikes. It thus, with our present mining laws in force, opened unending possibilities of contention, so long as the two mines were under separate ownership. One of the most remarkable instances of this tendency seems to be developing on the main Gold King level, about 400 feet west of the adit crosscut. Here a large, flat body of ore, continuous with the ore of the main Gold King lode, has been followed out for 30 or 40 feet to the northwest with a very gentle northwest dip. This ore apparently rests upon the top of a large horse, as in the northern part of the stope the dip of the ore is now found to be suddenly increasing. Possibly a still more striking case is the relation between the Gold King and Davis lodes. It seems very probable that these are not distinct, but merely branches of a very large, irregular stringer lead separated by a large horse of country rock, in which case they may be expected to come together in dip and strike.

At the point where it is reached by the adit crosscut (which runs nearly north) the Gold King lode is faulted by the so-called "Red vein," which has a northwesterly course and dips northeast about 75°. The horizontal displacement is about 30 feet, the northeast portion of the Gold King being thrown to the northwest. A supposed "bend" in the Gold King lode on the level below is almost certainly the same fault. The Red vein contains rhodonite (hence its name), which is not found in the Gold King and Davis lodes. It contains no ore of value, as far as known.

The characteristic ore of the Gold King and Davis lodes consists of white quartz with abundant pyrite, often showing banding by disposition. The pyrite, when massive and nearly free from quartz, is of little value in the Gold King lode, but carries gold in the Davis lode. The best ore always contains quartz, which may occasionally show some free gold. Galena, usually fine granular, occurs in bunches, being more abundant in some portions of the lodes than in others. As a whole, the ore is low grade, and probably no mine in the quadrangle can set as small nether value for workable ore.

Extensive preparations are being made for the future working of this property. The American tunnel cuts what is thought to be the same lode at a vertical distance of several hundred feet below the present adit; while a second tunnel, about 700 feet in length in September, 1900, is being driven from the mill at Gladstone. This will eventually tap the lode about 1,500 feet below the present workings.

The ore is carried down to the mill at Gladstone on a well-built Bleichert wire-rope tramway, running from 300 to 400 buckets of 700 or 800 pounds per day. A second tramway is being built to the American tunnel. The mill is equipped with a Gates crusher, 80 stamps, and 40 Frue vanners. Power is supplied by a 250-horsepower Westinghouse engine. The free gold is amalgamated, but the bulk of the product is in the concentrates, which are shipped to the smelter. The owners of the Gold King built and control the narrow-gauge railway from Silverton to Gladstone.

Tungsten ore deposits.—The Adams claim, which has for several years furnished cabinet specimens of the tungstate hübnerite, lies on the western slope of Bonita Peak at an elevation of about 11,300 feet. The hübnerite occurs in a lode which strikes N. 10° E. and dips east about 85°. In the main it is a sheeted zone 3 or 4 feet wide, in altered andesite of the Silverton series, the fissures being filled with quartz and fluorite. The individual stringers or veinlets of the lode are rarely more than 6 inches wide and are adherent or "frozen" to the walls. The hübnerite does not occur in all portions of the lode, but in isolated and irregular bunches, streaks, or nests of bronze-brown radial crystals embedded in quartz and fluorite. The development of this deposit is very superficial, consisting of a short tunnel and some open cuts, and the tungsten ore has never been worked on a commercial scale. The prospect was evidently opened in search of other ore, as the hübnerite has been thrown with the waste on the dump.

In Dry Gulch hübnerite occurs in a strong lode, on which have been located the Dawn of Day, Sunshine, and Minnesota claims. This lode has a course of about S. 60° E. and dips southwest at 65°. Several prospecting openings have been made on it on the south side of the gulch. One of these shows a solid vein of quartz 3 or 4 feet wide in Silverton andesite. The hübnerite occurs in the quartz in two or three small streaks, from 1 to 3 inches wide, and in small isolated bunches. The crystals are smaller than those in the Adams lode.

Owing to its weight (sp. gr., 7.2) and its occurrence in otherwise nearly barren quartz and fluorite, the hübnerite of Cement Creek can be readily and cleanly concentrated. Some 5 tons of concentrates have been produced from the Dry Gulch claims; but whether the material occurs in sufficient abundance and in sufficiently continuous bodies to pay for mining is a question not yet decided.

In its occurrence the hübnerite is purely a vein mineral, occurring in a quartz or quartz and fluorite gangue, as do galena, pyrite, and other ore minerals of the region.

Red and Bonita mine.—The adit tunnel of this mine runs in an easterly direction into Bonita Mountain, from a point about 100 feet bove Cement Creek. About 3,000 feet of work has been done from this tunnel, but the ore could not be made to pay and the attempt was abandoned. The workings are no longer accessible and the lode was not seen. The Red and Bonita mill is equipped with Gates crusher, 2 sets of rolls, jigs, 10 stamps, and 4 Frue vanners.

Queen Anne mine.—This is near the mouth of Ross Basin, on a lode which here consists of two or more parallel veins close together. The one worked in the Queen Anne strikes N. 50° E. and dips northwest at 85°. It consists of solid banded quartz and bismuthiferous galena ore up to 2 feet wide, "frozen" to the walls. Toward the southwest the vein pinches and carries a little gouge. It could not be traced on the surface beyond a large northwest-southeast lode which passes up into Ross Basin.

Columbia mine.—This, one of the oldest mines of the quadrangle, lies just northeast of the Queen Anne and is apparently on the same lode. It has been an intermittent producer of argentiferous galena ore on a small scale.

Ross Basin lodes.—There is at present no mine in operation in Ross Basin, and none of the developments have thus far passed beyond the prospecting stage, but the basin is traversed by several lodes of unusual size with well-exposed croppings. The most prominent one has a nearly northwest course and dips southwest at 80°. It outcrops boldly along the northeast side of the basin, especially near the head of the latter, where it passes over the ridge into Sunnyside Basin and is apparently the same as the George Washington lode. Toward the northwest it continues probably into Grey Copper Gulch. Some ore, resembling in mineralogical character that found in Sunnyside Basin, but apparently in irregular bunches, occurs in this huge lode, which is often over 50 feet wide. Several other lodes with nearly northeast courses come into the main lode from the southwest, but can not as a rule be traced on the surface to the northeast. The lodes shown on the map are only a few of those which traverse the floor of the basin in various directions, although most of them have a northeast trend. They are not all of great length, for one vein often stops short at the junction with a second vein of different course. In one case two well-exposed, strong quartz veins, one striking southwest and the other S. 80° W., come together in a massive cropping of quartz, beyond which there is no surficial sign of the continuation of either lode. Distinct evidence of one lode faulting another could not be obtained. They are apparently all of substantially the same age. The fissure fillings are usually solid white quartz with a little rhodonite and bunches of low-grade ore. In some cases the lodes contain numerous fragments of altered mineralized country rock.

Henrietta mine.—This property, in Prospect Gulch, is on a lode striking S. 40° W. and dipping northwest at 65°. Three tunnels on the south side of the gulch give access to the workings, while a fourth tunnel, destined to be the future main adit, is being driven to the westward to intersect the lode from a point about 150 feet above the bottom of the gulch. All the workings are in andesitic rocks, chiefly breccias, of the Silverton series. The ore occurs in a brecciated zone which is usually from 3 to 5 feet wide. The hanging and foot walls are well defined by planes of recent slipping, that on the hanging wall being especially regular and continuous. These slip planes usually contain a little soft gouge. Between these walls the ore occurs in stringers and bunches, partly replacing the shattered country rock included within the breccia zone. It consists of pyrite and chalcopyrite and occasionally a little galena. Pyrite is very abundant, occurring in solid masses, which, however, are not mined unless they contain chalcopyrite. Next the hanging wall there is a persistent seam, sometimes a foot in width, which consists of crushed country rock with sometimes a little white quartz. This portion of the lode is worthless, although a little sphalerite and tetrahedrite are said to occur in the quartz. No quartz was seen with the pay ore. The lode is not everywhere productive. There are frequent barren intervals, where the space between the walls is filled with broken and altered country rock impregnated with pyrite. The wall rock is impregnated with pyrite for at least 150 feet from the lode, but no ore is mined outside of the walls of the fissure.

The ore is low grade as a whole, containing from 0.05 to 0.1 ounce of gold and 12 to 30 ounces of silver per ton, with up to 30 per cent of copper. In 1900 the mine was reopened after some years of idleness, and it was proposed to treat the ore in a new smelter then nearing completion at the point where Cement Creek enters Bakers Park.

The lowest tunnel, which in September, 1900, had a length of about 550 feet and had not yet cut the lode, exhibits well the rather remarkable mineralization of the Silverton breccias in this vicinity. All the rock passed through is heavily impregnated with fine pyrite and frequently contains small sporadic bunches and stringers of galena and sphalerite. In some places the andesitic breccia has been locally silicified.

The Henrietta lode is of theoretic interest from the fact that the ore, in its freedom from quartz, presence of kaolin, and partial replacement of country rock, as well as in mineralogical character, is similar to the ores occurring in the stock deposits of Red Mountain. At the Henrietta, however, it is found, not in stock, but in a distinct fissure.

Other mines and prospects.—From Prospect Gulch southward to Silverton are many prospects along Cement Creek and in the side gulches. None of them are yet of much importance and not all were visited. The most ambitious of these is the Yukon tunnel of the Boston and Silverton Mining Company. No ore has yet been produced, but the tunnel is supplied with a new mill equipped with Blake crusher, rolls, jigs, 10 stamps, 2 Wilfley tables, and 4 Frue vanners. The power is steam.

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PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Bulletin No. 182.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Bulletins, (4) Mineral Resources, (5) Water-supply and Irrigation Papers, (6) Topographic Atlas of United States—folios and separate sheets thereof, (7) Geologic Atlas of United States—folios thereof. A circular giving complete lists may be had on application.

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Department of the interior | — | Bulletin | of the | United States | geological survey | no. 182 | Series A, Economic geology, 12 | [Seal of the department] |

Washington | government printing office | 1901

Second title: United States geological survey | Charles D. Walcott, director | — | A report | on the | economic geology | of the | Silverton quadrangle, Colorado | by | Frederick Leslie Ransome | [Vignette] |

Washington | government printing office | 1901

8°. 265 pp., 16 pl.

Author.

Ransome (Frederick Leslie)

United States geological survey | Charles D. Walcott, director | — | A report | on the | economic geology | of the | Silverton quadrangle, Colorado | by | Frederick Leslie Ransome | [Vignette] |

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[UNITED STATES. *Department of the interior.* (*U. S. geological survey.*) Bulletin 182.]

DEPARTMENT OF THE INTERIOR

BULLETIN
OF THE
UNITED STATES
GEOLOGICAL SURVEY

No. 183

SERIES F, GEOGRAPHY, 25

WASHINGTON
GOVERNMENT PRINTING OFFICE
1901

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

A
GAZETTEER OF PORTO RICO

BY

HENRY GANNETT

WASHINGTON
GOVERNMENT PRINTING OFFICE
1901

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., June 11, 1901.

SIR: I have the honor to transmit herewith, for publication as a bulletin, a gazetteer of Porto Rico. The place names here given are derived mainly from the report of the recent census of the island and from the War Department map, on the scale of 1:150,000.

It is my belief that the publication of this bulletin will go far toward preventing conflicts in the spelling of these place names.

Very respectfully,

HENRY GANNETT,
Geographer.

Hon. CHARLES D. WALCOTT,
Director U. S. Geological Survey.

A GAZETTEER OF PORTO RICO.

By Henry Gannett.

INTRODUCTION.

Porto Rico is the fourth in size of the West Indian Islands, being exceeded by Cuba, Haiti, and Jamaica. Its area, as measured from the best map available—that issued in 1899 by the War Department, on a scale of 1:150,000—is 3,600 square miles. There is, however, much uncertainty concerning the accuracy of these figures, as the coast line of the island has never been carefully surveyed. It lies east of Haiti, between latitudes 17° 50′ and 18° 30′ N., and between longitudes 65° 30′ and 67° 15′ W.

Under the jurisdiction of Porto Rico, as a colony of Spain and subsequently as a dependency of the United States, are included, besides the island of Porto Rico, the small islands Vieques and Culebra to the east and Mona to the west, as well as a number of islets adjacent to the coast.

The Indian name of the island was Borinquen. The name Porto Rico is a corruption of the proper name Puerto Rico, and is the form which has been in common use for centuries among English-speaking nations; the form Puerto Rico (rich harbor) being that in use by the residents of the island, by all Spanish-speaking peoples, and generally by other nations. The United States Board on Geographic Names, pursuing its principle of following local usage, adopted this form several years ago. Since the acquisition of the island by the United States, usage, even in the publications of the United States Government, became divided, some of them following the above decision, others using the form Porto Rico. In this condition of affairs, the Board appealed to the President of the United States for a decision, and the President decided in favor of Puerto Rico. Subsequently, however, in the Foraker bill for the government of Porto Rico, a clause was incorporated providing that the name be Porto Rico. This bill, agreed to by both Houses of Congress and signed by the President, became law, and thus established the spelling of the name.

Porto Rico is roughly rectangular in shape, with a length from east to west of about 100 miles and a breadth of about 35 miles. Its coast line is simple, with few good harbors, that of San Juan, the capital, on the north coast, being the best. The island is traversed through its length by a range of hills, which, starting at the northwest corner, swings in a broad curve southeast, then east, and finally northeast to the northeast corner. This range forms the main watershed of the island, and throughout most of its extent lies south of the middle of the island, giving longer courses, gentler slopes, and greater drainage basins to the northward-flowing streams, those flowing south having steep descents and short courses. These hills range in height from 2,000 feet in the gaps to 3,800 feet on the highest summits, the most elevated point in the island being El Yunque, at the northeast extremity of the range. These hills have considerable breadth, and within them the streams have cut deep valleys, giving to most of the island a steep, hilly surface. The coasts are in most parts bordered by broad extents of low, level lands.

None of the streams are navigable except for a mile or two near their mouths, where they are, in effect, estuaries.

Most of the area of Porto Rico has for centuries been divided into farms, and more than one-fifth of the island is under cultivation; hence the forested areas are few and small and of little importance. Timber is very scarce and most of that used in building is imported.

Lying within the Tropics, Porto Rico is within the region of the northeast trade winds. The annual temperature at San Juan, on the north coast, ranges from 78° to 82°. The range of monthly temperature is from 75° in January to 82° in August, while the maximum temperature on record is 99° and the minimum is 57°, indicating a very uniform climate. On the hills of the interior the temperature is, of course, lower. The annual rainfall at San Juan is 60 inches, and on the northeast coast is greater, reaching 100 inches, while in the southern part of the island it is much less, so much so that in some localities irrigation is necessary for the cultivation of crops.

Porto Rico is divided, for governmental purposes, into 7 departments and 69 municipal districts or *terminos municipales*. These in turn are subdivided into *barrios*.

Discovered by Columbus in 1493 and visited frequently in succeeding years, the island was not colonized by the Spaniards until 1509, when San Juan, at first called Caprera and later Puerto Rico, was founded and possession was taken of the entire island. In 1597 it was captured by the English, who, however, soon withdrew, and from that time until possession was taken by this country in 1898 Spain has held the island, although several attempts have been made upon it by the forces of various countries. During all this period Porto Rico has been free from internal dissensions, such as have repeatedly wasted the neighboring island of Cuba.

The population of Porto Rico in 1899 was little short of a million—953,243. The following table gives the population at various periods:

Year.	Population.	Rate of increase per decade.
		Per cent.
1765	44,883	-
1775	70,250	57
1800	155,426	37
1815	220,892	26
1832	330,051	27
1846	447,914	24
1860	583,308	21
1877	731,648	14
1889	798,565	09
1899	953,243	16

The density of population, or the number of inhabitants to a square mile, was in 1899, 264. The island is very thickly populated, especially when one considers that nearly all the population is rural. Few of the States of this country are as densely populated.

The following table gives the area, population, and density, by departments, in 1899.

Departments.	Area.	Population.	Density of population.
	Square miles.		
Aquadilla	240	99,645	415
Arecibo	621	162,308	261
Bayamon	542	160,046	295
Guayama	561	111,986	200
Humacao	413	88,501	214
Mayaguez	407	127,566	313
Ponce	822	203,191	247

The urban population forms but a small element, there being but four cities of more than 8,000 inhabitants each—San Juan, the capital, with 32,048; Ponce, on the south coast, 27,952; Mayaguez, on the west coast, 15,187, and Arecibo, 8,008. These cities had a combined population of 83,195, or only 8.7 per cent of the total population.

In respect to sex, females outnumbered males by 8,721 only, the proportions being 49.5 per cent males and 50.5 per cent females.

As to race, there were 589,426 whites and 363,817 colored, or 61.8 per cent white and 38.2 per cent colored. These proportions have differed greatly at different times in the past, the colored having in early days been in the majority, as may be seen by the following table.

Year.	Percentage of—	
	White.	Colored.
1802	48	52
1812	46.8	53.2
1820	44.4	55.6
1827	49.7	50.3
1830	50.1	49.9
1836	52.9	47.1
1860	51.5	48.5
1877	56.3	43.7
1887	59.5	40.5
1899	61.8	38.2

Of the total colored in 1899, 83.6 per cent were reported as of mixed white and negro blood, only 16.4 per cent being pure negroes.

The following table shows the distribution, by percentages, of the white and colored in the seven departments.

	Percentage of—	
	White.	Colored.
Aquadilla	85.6	14.4
Arecibo	77.1	22.9
Mayaguez	64.3	35.7
Ponce	59.6	40.4
Guayama	50.7	49.3
Bayamon	48.9	51.1
Humacao	46.1	53.9

The colored are more numerous proportionally in the eastern than in the western part of the island, and more numerous near the seacoast than in the interior.

At the time of its discovery the island was well populated by Indians, who were promptly subjugated and enslaved by the Spaniards. Harsh treatment, labor, and disease rapidly reduced their numbers, so that by 1543 they were practically exterminated, and at the present time no trace of Indian blood is to be found in the island.

With the diminution in number of Indian slaves negro slaves began to be introduced, and throughout the eighteenth century and three-fourths of the nineteenth the slave trade was actively prosecuted, and ceased only about 1873, in which year negro slavery was abolished.

The number of foreign born was 13,872, or only 1.5 per cent of the population. More than half of these were of Spanish birth, and 43 per cent of them were found in the three largest cities.

As to conjugal condition, 69.7 per cent of the people were single; 16.6 per cent were married; 8.8 per cent were living together by mutual consent, having waived, mainly on account of its expense, the ceremony of marriage, and 4.9 per cent were widowed. The proportion of the single was very large, and that of the married, even if those living together by mutual consent be included, was very small. In part this may be accounted for by the fact, established by the census, that the proportion of children was very large and that of adults correspondingly small. There are few aged persons in the island.

Of the total population, only 16.6 per cent, or one-sixth, were able to read. The proportion was much greater in the large cities than in the rural districts, and was much larger among the whites than the colored.

The persons engaged in gainful occupations were 33.1 per cent of the total population, a proportion somewhat smaller than in the United States. This may probably be accounted for by the greater proportion of children in Porto Rico. Of the males, 56.9 per cent were breadwinners; of the females, only 9.9 per cent. Classifying the breadwinners by groups of occupations, it appears that 62.8 per cent of them were engaged in agriculture, 20.5 per cent in personal and domestic service, 8.4 per cent in manufactures, 7.6 per cent in trade and transportation, and 0.7 per cent in the professions. The leading occupation, in which more than two-thirds of the breadwinners were engaged, was that of labor.

Of the entire area of Porto Rico, 3,606 square miles, including the adjacent islands, 2,743 square miles were, in 1899, included within farms. This is 76 per cent of the area. The land under cultivation was 747 square miles, or 21 per cent of the total area, a proportion larger than that cultivated in the United States, and yet a small proportion when one considers the density of the population and the fact that it is almost entirely rural. There were 39,021 farms, with an average area of only 45 acres and an average cultivated area of but 12 acres. In the United States the average area under cultivation per farm in 1890 was 78 acres. Ownership of farms was almost universal, not less than 93 per cent of the farms and 91 per cent of the farm area being owned by their occupants. The farms owned by whites were, as a rule, larger than those owned by the colored.

The leading farm product of Porto Rico is coffee, which was planted upon not less than 41 per cent of the total cultivated area. While coffee was produced in all parts of the island, its culture is more general in the hilly central and western parts. Sugar cane holds second rank as a product, occupying 15 per cent of the cultivated lands, its area of cultivation being mainly the coast lands all around the island. Bananas occupied 14 per cent of the cultivated land; sweet potatoes, 8 per cent; indian corn, 4 per cent; rice, 2 per cent; cocoanuts, 2 per cent, and tobacco only 1 per cent of the cultivated land.

Manufactures are few and of trifling importance. No mining of any kind is at present carried on in the island, although in times past valuable gold placers were worked by the Spaniards. It is by no means improbable that thorough prospecting may develop valuable mineral resources hitherto unsuspected.

Means of internal communication are very scanty. There are altogether 159 miles of railroad in the island, but they are in disconnected pieces and closely parallel the coast, none extending into the interior. There is one good wagon road extending across the island from San Juan to Cayey and thence to Ponce, with a branch from Cayey to Guayama, and short roads in other directions, the total length of good roads in the island being about 285 miles. These were built by the Spanish authorities for military purposes. Aside from these, the so-called roads of the island are mere trails, few of them passable for wheeled vehicles at any time, and commonly only for saddle animals or foot travel.

As a result of this condition, internal trade is very small in volume and is confined mainly to the coast line. Indeed, there are few civilized communities whose individuals are so nearly isolated and have so little intercommunication as this.

In 1897 the total assessed value of property was $28,867,928, and the true value was estimated to be $150,000,000, or about $170 per capita of the population. The average per capita wealth of the people of the United States is estimated to be in excess of $1,000, a comparison which speaks volumes concerning the poverty of the people of Porto Rico. The mortgage indebtedness of the people in 1897 was not less than $18,610,000.

In 1899 the facilities for education consisted, in the main, of public schools. Of 467 schools 412 were maintained at public expense, the remainder being private schools. All the schools had a seating capacity of but 29,164. The number of teachers was 623, and the number of pupils in attendance was 27,018. The number of children attending school was but a small part of those of school age. The prevailing religion is, of course, the Catholic, with which church practically all the population are connected.

GAZETTEER.

Abra Honda; barrio in municipal district Camuy, department of Arecibo. Population 1,420.

Abras; barrio in municipal district Corozal, department of Bayamon. Population 1,183.

Aceituna; barrio in municipal district Moca, department of Aquadilla. Popultion 1,067.

Aceituna, Cerro; mountains in western part of department of Ponce.

Achiote; barrio in municipal district Naranjito, department of Bayamon. Population 1,094.

Adjuntas; municipal district in department of Ponce. Area 84 square miles. Population 19,484.

Adjuntas; city and post-office in department of Ponce, situated in the mountains. Population 1,963.

Adjuntas, Rio de Las; a right-hand tributary of Rio Guanajibo, in the western part of the island.

Afligidos, Punta; point on southern coast near Guanica.

Aguacate; barrio in municipal district Aguadilla, department of Aguadilla.

Aguacate; barrio in municipal district Yabucoa, department of Humacao. Population 1,374.

Agüada; municipal district in the department of Aguadilla. Area 15 square miles. Population 10,581.

Aguada; city and post-office near the coast in the department of Aguadilla. Population 1,135.

Aguadilla; a department occupying the northwestern part of the island. Its area is 240 square miles and its population 99,645. The number of inhabitants to the square mile is 415, making it the most densely settled of the departments. The population consists of 85.6 per cent whites and 14.4 per cent colored, the proportion of colored being smaller in this department than in any other. The cultivated area constitutes not less than 35 per cent of the total area of the department, and of this cultivated area not less than 43 per cent is planted in coffee trees. Of the total farm area 93 per cent is owned by its occupants and only 7 per cent is rented.

Aguadilla; municipal district in department of Aguadilla. Area 34 square miles. Population 17,830.

Aguadilla; coast city and post-office in department of Aguadilla. Population 6,425.

Aguas Blancas; barrio in municipal district Yauco, department of Ponce. Population 1,170.

Aguas Buenas; municipal district in department of Guayama. Area 31 square miles. Population 7.977.

Aguas Buenas; interior city and post-office, department of Guayama. Population 1,309.

Aguerre, Puerto de; harbor on southern coast.

Aguila, Punta del; the southwest point of the island.

Aguirre; barrio in municipal district Salinas, department of Guayama. Population 1,291.

Agustin, Punta de; point on north coast near Rio Grande.

Aibonita; barrio in municipal district San Sebastian, department of Aguadilla. Population 998.

Aibonito; municipal district in department of Ponce. Area 35 square miles. Population 8,596.

Aibonito; city and post-office in department of Ponce, situated in the mountains. Population 2,065.

Aibonito; barrio in municipal district Hatillo, department of Arecibo. Population 1,606.

Ala de la Piedra; barrio in municipal district Barros, department of Ponce.

Algarroba, Punta; point on west coast.

Algarrobo; barrio in municipal district Vega Baja, department of Bayamon. Population 877.

Algarrobo; barrio in municipal district Guayama, department of Guayama.

Algarrobo; barrio in municipal district Mayagues, department of Mayagues. Population 1,054.

Algarrobo: barrio in municipal district Aibonito, department of Ponce.

Algarrobo, Cerro; hills near west coast, Mayagues district.

Algarrobos; barrio in municipal district Yauco, department of Ponce. Population 952.

Algodones, Cayo; islet off eastern coast.

Algodones, Enseñada; bay on eastern coast,

Almacigo Alto; barrio in municipal district Yauco, department of Ponce.

Almacigo Bajo; barrio in municipal district Yauco, department of Ponce. Population 798.

Almirante Norte; barrio in municipal district Vega Baja, department of Bayamon. Population 902.

Almirante Sur; barrio in municipal district Vega Baja, department of Bayamon. Population 847.

Altosano; barrio in municipal district San Sebastian, department of Aguadilla.

Alto Songo; barrio in municipal district Las Marias, department of Mayaguez. Population 885.

Añasco; municipal district in department of Mayaguez. Area 42 square miles. Population 13,311.

Añasco; city in department of Mayaguez. Population 3,483.

Añasco Arriba; barrio in municipal district of Añasco, department of Mayaguez.

Añasco Abajo: barrio in municipal district Añasco, department of Mayaguez.

Ancones; barrio in municipal district Arroyo, department of Guayama.

Ancones; barrio in municipal district San German, department of Mayaguez.

Andreas Ruiz, Quebrada; ravine on northern coast near Quebradillas.

Angeles; barrio in municipal district Utuado, department of Arecibo. Population 2,456.

Angeles, Rio; head branch of Rio Camuy, in Arecibo department.

Anon; barrio in municipal district Ponce, department of Ponce. Population 1,734.

Anones; barrio in municipal district Naranjito, department of Bayamon. Population 1,420.

Anones; barrio in municipal district Las Marias, department of Mayaguez. Population 1,251.

Antiguo, Puerto; harbor on northern coast near Quebradillas.

Anton Ruiz; barrio in municipal district Humacao, department of Humacao. Population 987.

Anton Ruiz, Rio: a small stream in the eastern part of the island.

Apeadero; barrio in municipal district Patillas, department of Humacao.

Aponte, Cerro; hills in department of Guayama.

Aquila, Punta del; point on northwest coast.

Arecibo; a department in the northern part of the island, lying west of Bayamon. Its area is 621 square miles and the population 162,308, with 261 to the square mile. As to race, the population was divided in the proportion of 77.1 per cent white and 22.9 per cent colored. Of the total area 25 per cent, or one-fourth, was under cultivation, and of this cultivated area 50 per cent was planted in coffee. Of the total farm area 97 per cent, or very nearly all, was owned by its occupants, only 3 per cent being rented.

Arecibo; municipal district in department of Arecibo. Area 133 square miles. Population 36,910.

Arecibo; coast city and post-office in department of Arecibo. Population 8,008.

Arecibo, Fondeadero de; anchorage in open bay of same name.

Arecibo, Rio Grande de; river, heading in the main range of the island and flowing north to northern coast, at Arecibo. Length 30 miles.

Arenales; barrio in municipal district Aguadilla, department of Aguadilla.

Arenales Altos; bario in municipal district of Isabela, department of Aguadilla. Population 1,559.

Arenales Bajos; barrio in municipal district Isabela, department of Aguadilla. Population 883.

Arenas; barrio in municipal district Cidra, department of Guayama.

Arenas; barrio in municipal district Utuado, department of Arecibo. Population 1,577.

Arenas, Cayo; islet off southern coast.

Arenas, Punta; point on southern coast, near Salinas.

Arenas, Punta; point on western coast.

Arenalejos; barrio in municipal district Arecibo, department of Arecibo. Population 1,228.

Armuelas; barrio in municipal district Juana Diaz, department of Ponce. Population 1,010.

Arrecifes de la Cordillera; islets off northeast coast.

Arroyo; city and post-office in department of Guayama, situated near the coast. Population 2,137.

Arroyo; municipal district in department of Guayama. Area 22 square miles. Population 4,867.

Arroyo, Rio del; a small stream in the southeastern part of the island.

Arrozal; barrio in municipal district Arecibo, department of Arecibo. Population 1,662.

Asomante; barrio in municipal district Aibonito, department of Ponce.

Asomante; barrio in municipal district Aguada, department of Aguadilla.

Asomante, Cerro; hills in southeastern part of department of Bayamon.

Asomante, Cerro; hills near Humacao.

Atalaya; barrio in municipal district Rincon, department of Aguadilla.

Atalaya; barrio in municipal district Aguada, department of Aguadilla.

Avillas, Cerro; hills in southwest part of department of Ponce.

Avispas, Cerro; hills near Guayama.

Bahomamey; barrio in municipal district San Sebastian, department of Aguadilla.

Bairoa; barrio in municipal district Aguas Buenas, department of Guayama.

Bairoa; barrio in municipal district Caguas, department of Guayama.

Bairo, Rio; a left-hand branch of Loiza River.

Bajo; barrio in municipal district Patillas, department of Humacao.

Bajo, Punta del; point on southeastern coast.

Bajura; barrio in municipal district Cabo Rojo, department of Mayaguez. Population 1,218.

Bajura; barrio in municipal district Isabela, department of Aguadilla. Population 647.

Bajura; barrio in municipal district Vega Alta, department of Bayamon. Population 749.

Bajura Adentra; barrio in municipal district Manati, department of Arecibo. Population 881.

Bajura Afuera; barrio in municipal district Manati, department of Arecibo. Population 739.

Ballaja; barrio in municipal district San Juan, department of Bayamon. Population 1,217.

Ballena, Ensenada de; harbor on southern coast, near Guanica.

Bandera, Cerro de la; hills near Humacao.

Bandera, Punta de la; point on northeast coast, near Luquillo.

Barahona; barrio in municipal district Morovis, department of Arecibo. Population 854.

Barceloneta; municipal district in department of Arecibo. Area 43 square miles. Population 9,357.

Barceloneta; city and post-office in department of Arecibo, situated near the coast. Population 1,459.

Barceloneta; barrio in municipal district Barceloneta, department of Arecibo. Population 1,459.

Barinas; barrio in municipal district Yauco, department of Ponce. Population 1,432.

Barraces, Punta; point at entrance to Guayanilla Harbor, on southern coast.

Barrancas; barrio in municipal district Barranquitas, department of Ponce. Population 692.

Barrancas, Punta de; point on eastern coast.

Barrancas, Punta; point on southern coast, near Guayama.

Barranquitas; municipal district in department of Ponce. Area 48 square miles. Population 8,103.

Barranquitas; post village in department of Ponce.

Barreal; barrio in municipal district Penuelas, department of Ponce. Population 922.

Barrero; barrio in municipal district Guayanillo, department of Ponce.

Barros; municipal district in department of Ponce. Area 76 square miles. Population 14,845.

Barros; post village in department of Ponce.

Barros; barrio in municipal district Barros, department of Ponce. Population 987.

Bartolo; barrio in municipal district Lares, department of Aguadilla. Population 2,035.

Batato, Cayo; islet off southeastern coast.

Bateria, Punta de la; point on eastern coast, near Fajardo.

Bateyes; barrio in municipal district Mayaguez, department of Mayaguez. Poplation 1,019.

Baucal, Cerro; hills near Penuelas, department of Ponce.

Bauta Abajo; barrio in municipal district Barros, department of Ponce. Population 1,603.

Bauta Arriba; barrio in municipal district Barros, department of Ponce.

Bauta, Rio; head branch of Manati River in department of Arecibo.

Bayamon; a department occupying part of the northern portion of the island. Its area is 542 square miles and its population 160,046. The density of population is 295 per square mile. As to race, the population was divided in proportion of 48.9 per cent white and 51.1 per cent colored, the latter being slightly in excess. Of the total area 13 per cent was under cultivation, and of this cultivated area 27 per cent was planted in sugar cane and 20 per cent in coffee. Of the total farm area 81 per cent was owned by its occupants and 19 per cent rented.

Bayamon; municipal district in department of Bayamon. Area 77 square miles. Population 19,940.

Bayamon; city and post-office in department of Bayamon, situated near the coast. Population 2,218.

Bayamon; barrio in municipal district Cidra, department of Guayama.

Bayamon, Rio; river heading near Aguas Buenas, and flowing north to its mouth near San Juan. Length 25 miles.

Bayamoncito; barrio in municipal district Aguas Buenas, department of Guayama. Population 765.

Bayamoncito, Rio; the head stream of Bayamon River.

Bayaney; barrio in municipal district Hatillo, department of Arecibo. Population 1,394.

Beatriz; barrio in municipal district Caguas, department of Guayama. Population 868.

Beatriz; barrio in municipal district Cayey, department of Guayama.

Beatriz; barrio in municipal district Cidra, department of Guayama.

Bejucos; barrio in municipal district Isabela, department of Aguadilla. Population 1,257.

Benavente; barrio in municipal district Hormigueros, department of Mayaguez.

Berberia, Cayos de; islets off southern coast near Santa Isabel.

Bermeja, Punta; point on southern coast near Guanica.

Bermejales; barrio in municipal district Barros, department of Ponce. Population 1,317.

Bibiana, Cerro; mountains near Hato Grande.

Blanco, Cerro; hills in department of Ponce.

Blanco, Rio; a river of the northwestern part of the island, heading in the mountains. Length 36 miles.

Blanco, Rio; a small stream in the eastern part of the island.

Boca; barrio in municipal district Guayanilla, department of Ponce.

Boca; barrio in municipal district Santa Isabel, department of Ponce.

Boqueron; barrio in municipal district Piedras, department of Humacao.

Boqueron; barrio in municipal district Cabo Rojo, department of Mayaguez. Population 1,185.

Boqueron, Punta del; Point on northwestern coast.

Boqueron, Enseñada del; harbor on southwestern coast.

Boqueron, El; island off northern coast, near San Juan.

Boquillas, Punta de las; point on northern coast near Manati.

Borassa Alto; barrio in municipal district Carolina, department of Bayamon. Population 889.

Borassa Bajo; barrio in municipal district Carolina, department of Bayamon. Population 764.

Borinquen; barrio in municipal district Aguadilla, department of Aguadilla. Population 1,271.

Borinquen; barrio in municipal district Caguas, department of Guayama.

Borinquen, Punta; point on northwest coast.

Botijas; barrio in municipal district Barros, department of Ponce. Population 891.

Bramadero, Punta; point on western coast.

Brea, Punta de la; point on southern coast near Guanica.

Brenas, Punta de las; point on northern coast near Vega Baja.

Brusi, Peñon de; point on northern coast near Camuy.

Bucana-Vayas; barrio in municipal district Ponce, department of Ponce. Population 1,315.

Bucana, Rio; a small stream in the southern part of the island.

Bucarabones; barrio in municipal district Las Marias, department of Mayaguez. Population 761.

Bucarabones; barrio in municipal district Maricao, department of Mayaguez. Population 1,854.

Bucarabones, Rio; a left-hand tributary to Rio Blanco in the northwest.

Bucarabones, Sierra; mountains in eastern part of Mayaguez department.

Buenos Aires; barrio in municipal district Lares, department of Aguadilla. Population 1,449.

Buenos Aires, Cuchilla de; short mountain range in northwestern part of department of Ponce.

Buena Vista; barrio in municipal district Bayamon, department of Bayamon. Population 1,028.

Buena Vista; barrio in municipal district Humacao, department of Humacao. Population 985.

Buena Vista; barrio in municipal district Las Marias, department of Mayaguez. Population 1,120.

Buena Vista, Cerro; hills in Añasco district, in the western part of the island.

Buena Vista, Cerro; hills in department of Guayama.

Burones, Cerro; hills in department of Ponce.

Cabazas,-Cabo; Northeast cape of island.

Cabezas; barrio in municipal district Fajardo, department of Humacao.

Cabeza Chiquita; headland on northeast coast near Fajardo.

Cabezade Piñeiro; point on island of same name off east coast.

Cabo Caribe; barrio in municipal district Vega Baja, department of Bayamon. Population 277.

Cabo Rojo; municipal district in department of Mayaguez. Area 55 square miles. Population 16,154.

Cabo Rojo; city and post-office, in department of Mayaguez, situated near the coast. Population 2,744.

Cabra, Isla; island at entrance of San Juan Harbor.

Cabra de Tierra; point at entrance to Hondo Enseñada, on eastern coast.

Cabras, Isla; island off eastern coast.

Cabrillon, Punta; point on southern coast near Ponce.

Cabrita, Isla; small island at entrance of San Juan Harbor.

Cabritas, Isla; island off eastern coast.

Cabro, Cerros del; mountains in department of Guayama.

Cacao; barrio in municipal district Carolina, department of Bayamon. Population 1,225.

Cacao Alto; barrio in municipal district Patillas, department of Humacao.

Cacao Bajo; barrio in municipal district Patillas, department of Humacao.

Cacaos; barrio in municipal district Barros, department of Ponce.

Cacaos; barrio in municipal district Quebradillas, department of Arecibo. Population 1,066.

Caguabo; barrio in municipal district Añasco, department of Mayaguez.

Caguana; barrio in municipal district Utuado, department of Arecibo. Population 2,555.

Caguas; municipal district in department of Guayama. Area 60 square miles; population 19,857.

Caguas; interior city and post-office in department of Guayama. Population 5,450.

Caguitas; barrio in municipal district Aguas Buenas, department of Guayama. Population 856.

Caguitas, Rio; a left-hand branch of Loiza River.

Caimital; barrio in municipal district Guayama, department of Guayama. Population 603.

Caimital Alto: barrio in municipal district Aguadilla, department of Aguadilla.

Caimital Bajo; barrio in municipal district Aguadilla, department of Aguadilla. Population 943.

Caimito; barrio in municipal district Juncos, department of Guayama.

Caimito; barrio in municipal district Yauco, department of Ponce.

Caimito Alto; barrio in municipal district Rio Piedras, department of Bayamon. Population 779.

Caimito Bajo; barrio in municipal district Rio Piedras, department of Bayamon. Population 927.

Cain Alto; barrio in municipal district San German, department of Mayaguez. Population 1,643.

Cain Bajo; barrio in municipal district San German, department of Mayaguez. Population 942.

Cain, Rio de; a right-hand branch of Rio Guanajibo, in the western part of the island.

Cain, Sierra de; mountains in eastern part of Mayaguez department.

Caja de Muertos; island and barrio in municipal district Ponce, department of Ponce. Population 64.

Calabazas; barrio in municipal district San Sebastian, department of Aguadilla. Population 746.

Calabazas; barrio in municipal district Yabucoa, department of Humacao. Population 1,891.

Calabeza, Cerro: hills in department of Guayama.

Calderon, Sillas de: mountains in western part of department of Ponce.

Caleta; barrio in municipal district San Juan, department of Bayamon. Population 3,307.

California; barrio in municipal district Aguada, department of Aguadilla.

Callado; barrio in municipal district Juana Diaz, department of Ponce.

Callejones; barrio in municipal district Lares, department of Aguadilla. Population 2,152.

Calvache; barrio in municipal district Rincon, department of Aguadilla. Population 708.

Calzada; barrio in municipal district Maunabo, department of Humaçao.

Camarones; barrio in municipal district Bayamon, department of Bayamon. Population 620.

Camaseyes; barrio in municipal district Aguadilla, department of Aguadilla. Population 1,633.

Cambalache; barrio in municipal department Arecibo, department of Arecibo. Population 470.

Camino Nuevo; barrio in municipal district Yabucoa, department of Humacao. Population 1,435.

Camuy; municipal district in department of Arecibo. Area 44 square miles; population 10,887.

Camuy; coast town and post-office in department of Arecibo.

Camuy; barrio in municipal district Camuy, department of Arecibo. Population 989.

Camuy, Rio: river in western part of Arecibo; flows north to north coast, between Camuy and Hatillo. Length 18 miles.

Cañabon; barrio in municipal district Caguas, department of Guayama. Population 1,309.

Cañabon; barrio in municipal district Barranquitas, department of Ponce. Population 1,117.

Cañaboncito: barrio in municipal district Caguas, department of Guayama. Population 1,400.

Cañas; barrio in municipal district Ponce, department of Ponce. Population 2,680.

Cañas, Rio; a left-hand branch of Rio Blanco, in the northwest.

Cañas, Rio: a small, left-hand branch of Rio Culebrinas, in the northwest.

Cañas, Rio; a stream in the southern part of the island.

Cañas, Rio; a left-hand branch of Loiza River.

Candelaria; barrio in municipal district Lajas, department of Mayaguez. Population 1,008.

Candelaria; barrio in municipal district Mayaguez, department of Mayaguez. Population 2,609.

Candelaria; barrio in municipal district Toa Baja, department of Bayamon. Population 1,395.

Candelaria; barrio in municipal district Vega Alta, department of Bayamon. Population 863.

Candelero Abajo; barrio in municipal district Humacao, department of Humacao. Population 972.

Candelero Arriba; barrio in municipal district Humacao, department of Humacao. Population 811.

Candelero, Rio; a small stream in the southeast.

Candelero, Punta; point on southeastern coast.

Cangrejos; barrio in municipal district Carolina, department of Bayamon. Population 367.

Cangrejos, Punta; point on northern coast, east of San Juan.

Caniaco; barrio in municipal district Utuado, department of Arecibo. Population 631.

Canovanas; post village in department of Bayamon.

Canovanas; barrio in municipal district Loiza, department of Bayamon. Population 1,942.

Canovanas, Rio; a right-hand branch of Loiza River.

Cantera; barrio in municipal district Ponce, department of Ponce. Population 5,321.

Cantera, Cerro de la; hills in department of Ponce.

Caonillas; barrio in municipal district Aibonito, department of Ponce.

Caonillas; barrio in municipal district Utuado, department of Arecibo. Population 2,378.

Caonilla Abajo; barrio in municipal district Juana Diaz, department of Ponce. Population 1,558.

Caonilla Arriba; barrio in municipal district Juana Diaz, department of Ponce Population 2,200.

Capa; barrio in municipal district Moca, department of Aguadilla. Population 893.

Capaes; barrio in municipal district Adjuntas, department of Ponce. Population 1,266.

Capaez; barrio in municipal district Hatillo, department of Arecibo. Population 1,016.

Capaez, Cerro de; mountains in northwestern part of Ponce department.

Capitanejo; barrio in municipal district Juana Diaz, department of Ponce. Population 1,338.

Capitanejo; barrio in municipal district Ponce, department of Ponce. Population 1,161.

Capo, Ensenada; harbor on southern coast, near Santa Isabel.

Caracol; barrio in municipal district Añasco, department of Mayaguez.

Caracol, Cerro; hills in western part of Mayaguez department.

Caracoles, Isla; islet off southwest coast.

Caracoles, Punta; point on north shore, east of Arecibo.

Caracoles, Penas de las; point on north coast, near Hatillo.

Carcel; barrio in municipal district Mayaguez, department of Mayaguez. Population 4,585.

Carcuero, Punta; point on southern coast, near Ponce.

Cardona, Isla; islet off southern coast, near Ponce, on which is a light-house.

Cariba, Cayo; islet off southern coast.

Caribes, Islas; islands off southern coast, near Guayama.

Carite; barrio in municipal district Guayama, department of Guayama. Population 834.

Carolina; municipal district in department of Bayamon. Area 57 square miles. Population 11,965.

Carolina; interior city and post-office in department of Bayamon. Population 2,177.

Carmen; barrio in municipal district Guayama, department of Guayama. Population 784.

Carraiza; barrio in municipal district Trujillo Alto, department of Bayamon. Population 1,159.

Carrayos, Enseñada; harbor on southern coast, near Santa Isabel.

Carrera; barrio in municipal district Arecibo, department of Arecibo. Population 676.

Carreras; barrio in municipal district Añasco, department of Mayaguez.

Carrizal; barrio in municipal district Aguada, department of Aguadilla.

Carrizales; barrio in municipal district Hatillo, department of Arecibo. Population 969.

Cascajo, Punta; point in entrance to Enseñada Honda, on eastern coast.

Casey, Abajo; barrio in municipal district Añasco, department of Mayaguez.

Casey Arriba; barrio in municipal district Añasco, department of Mayaguez.

Casey, Rio; a left-hand branch of Rio Blanco, in the northwestern part of the island.

Castillo, Cerro del; hills in the eastern part of department of Bayamon.

Cata, Cerro de; hills in department of Ponce.

Cataño; barrio in municipal district Bayamon, department of Bayamon. Population 2,331.

Cataño; barrio in municipal district Humacao, department of Humacao.

Cataño, Punta; point separating outer and inner harbor of San Juan, on north coast.

Catedral; barrio in municipal district San Juan, department of Bayamon. Population 2,497.

Caunilla, Rio; a right-hand tributary of Arecibo River, in department of Arecibo.

Cautagallos, Punta; point on northern coast, near Manati.

Cayaguas, Rio; a head branch of Loiza River.

Cayales; barrio in municipal district Coamo, department of Ponce. Population 989.

Cayey; municipal district in department of Guayama. Area 90 square miles. Population 14,442.

Cayey; interior city and post-office in department of Guayama. Population 3,763.

Cayey, Tetas de; mountains in eastern part of department of Ponce.

Cedrito; barrio in municipal district Comerio, department of Guayama.

Cedro; barrio in municipal district Cayey, department of Guayama.

Cedro Abajo; barrio in municipal district Naranjito, department of Bayamon. Population 977.

Cedro Arriba; barrio in municipal district Naranjito, department of Bayamon. Population 915.

Cedro, Cerrodel; hills near Cayey, department of Guayama.

Cedros; barrio in municipal district Carolina, department of Bayamon. Population 724.

Ceiba; barrio in municipal district Cidra, department of Guayama.

Ceiba; barrio in municipal district Fajardo, department of Humacao.

Ceiba; barrio in municipal district Vega Baja, department of Bayamon. Population 469.

Ceiba; coast city in department of Humacao. Population 1,314.

Ceiba Alta; barrio in municipal district Aguadilla, department of Aguadilla.

Ceiba Baja; barrio in municipal district Aguadilla, department of Aguadilla.

Ceiba Norte; barrio in municipal district Juncos, department of Guayama.

Ceiba Sur; barrio in municipal district Juncos, department of Guayama.

Cejas; barrio in municipal district Comerio, department of Guayama.

Celada; barrio in municipal district Gurabo, department of Guayama. Population 964.

Centro; barrio in municipal district Moca, department of Aguadilla. Population 601.

Cercadillo; barrio in municipal district Cayey, department of Guayama.

Cercadillo, Cerro; hills in department of Guayama.

Cercado; barrio in municipal district Añasco, department of Mayaguez.

Cerrillos; barrio in municipal district Ponce, department of Ponce. Population 518.

Cerro Gordo; barrio in municipal district Aguada, department of Aguadilla. Population 848.

Cerro Gordo; barrio in municipal district Anasco, department of Mayaguez.

Cerro Gordo; barrio in municipal district Bayamon, department of Bayamon. Population 845.

Cerro Gordo; barrio in municipal district Moca, department of Aguadilla. Population 1,008.

Cerro Gordo; barrio in municipal district San Lorenzo, department of Guayamo. Population 1,452.

Cerro Gordo, Playa de; beach on north coast, near Vega Baja.

Cerro Gordo, Isla de; small island off north coast, near Vega Baja.

Cerro Gordo, Punta de; point on north coast, near Vega Baja.

Cerrote; barrio in municipal district Las Marias, department of Mayaguez. Population 864.

Cerrotes, Los; mountains in western part of department of Ponce.

Chamorro; barrio in municipal district Las Marias, department of Mayaguez.

Charcas; barrio in municipal district Quebradillas, department of Arecibo. Population 330.

Chico, Rio; a small stream in the southeast.

Chiquita, Punta; point on northwest coast.

Chupacallos; barrio in municipal district Fajardo, department of Humacao.

Ciales; municipal district in department of Arecibo. Area 66 square miles. Population 18,115.

Ciales; interior city and post office, in department of Arecibo. Population 1,356.

Ciales; barrio in municipal district Ciales, department of Arecibo. Population 1,356.

Cialitos; barrio in municipal district Ciales, department of Arecibo. Population 2,522.

Cialitos, Rio; a left-hand branch of Manati River, in department of Arecibo.

Cibao; barrio in municipal district Camuy, department of Arecibo. Population 695.

Cibao; barrio in municipal district San Sebastian, department of Aguadilla.

Cibuco; barrio in municipal district Corozal, department of Bayamon. Population 1,096.

Cibuco; barrio in municipal district Vega Baja, department of Bayamon. Population 310.

Cibuco, Boca de; inlet at mouth of Cibuco River.

Cibuco, Rio; river in western part of Bayamon department, flowing north to coast. Length 15 miles.

Cidra; municipal district in department of Guayama. Area 39 square miles. Population 7,552.

Cidra; interior city in department of Guayama. Population 1,034.

Cidra; barrio in municipal district Anasco, department of Mayaguez.

Cidra, Rio de la: head branch of Arecibo River in department of Arecibo.

Cidrae; barrio in municipal district San Sebastian, department of Aguadilla.

Ciego Hernandez; barrio in municipal district Yauco, department of Ponce.

Cienega; barrio in municipal district Camuy, department of Arecibo. Population 711.

Cienega; barrio in municipal district Rio Grande, department of Bayamon. Population 1,610.

Ciervo, Cerro del; hills in eastern part of department of Arecibo.

Cintrona; barrio in municipal district Juana Diaz, department of Ponce. Population 1,132.

Coamo; municipal district in department of Ponce. Area 87 square miles. Population 15,144.

Coamo; interior city and post-office in department of Ponce. Population 3,244.

Coamo Arriba; barrio in municipal district Coamo, department of Ponce. Population 1,223.

Coamo, Rio de; a small stream in the southern part of the island.

Cocos: barrio in municipal district Quebradillas, department of Arecibo. Population 978.

Collado, Isla; islet off southwestern coast.

Collarro, Cuchilla de; hills near Juana Diaz.

Collores; barrio in municipal district Barros, department of Ponce.

Collores; barrio in municipal district Humacao, department of Humacao. Population 1,016.

Collores; barrio in municipal district Juana Diaz, department of Ponce. Population 2,835.

Collores; barrio in municipal district Yauco, department of Ponce. Population 893.

Collores, Cerro; hills in southeastern part of department of Arecibo.

Colores; barrio in municipal district Piedras, department of Humacao.

Comacho, Cerro; mountains in northern part of department of Ponce.

Comancho, Cerro; hills in southeastern part of department of Arecibo.

Comerio; municipal district in department of Guayama. Area 37 square miles. Population 8,249.

Comerio; interior city and post-office in department of Guayama. Population 1,191.

Comezon, El; bay on northeast coast near Rio Grande.

Concejo; barrio in municipal district Guayanillo, department of Ponce.

Conovanillas, Rio; a right-hand branch of Loiza River.

Consejo; barrio in municipal district Utuado, department of Arecibo. Population 929.

Contorno; barrio in municipal district Toa Alta, department of Bayamon. Population 653.

Convento, Punta del; point on southeast coast.

Corchones, Punta; point on southern coast.

Corcovado; barrio in municipal district Hatillo, department of Arecibo. Population 1,065.

Corcovado; barrio in municipal district Añasco, department of Mayaguez.

Corcovado, Punta; point on southern coast near Guanica.

Cordillera; barrio in municipal district Ciales, department of Arecibo. Population 1,425.

Coroza, Punta; point on northern coast, west of San Juan.

Corozal; municipal district in department of Bayamon. Area 35 square miles. Population 11,508.

Corozal; interior city and post-office in department of Bayamon. Population 1,057.

Corozal, Rio; a right-hand branch of Cibuco River, in Bayamon department.

Corrales; barrio in municipal district Aguadilla, department of Aguadilla.

Costa; barrio in municipal district Lajas, department of Mayaguez.

Coto; barrio in municipal district Isabela, department of Aguadilla. Population 1,349.

Coto; barrio in municipal district Manati, department of Arecibo. Population 2,110.

Coto; barrio in municipal district Pennelas, department of Ponce.

Coto-Laurel; barrio in municipal district Ponce, department of Ponce. Population 1,884.

Cotui; barrio in municipal district San German, department of Mayaguez. Population 811.

Cruces; barrio in municipal district Aguada, department of Aguadilla.

Cruz; barrio in municipal district Moca, department of Aguadilla. Population 954.

Cruz; barrio in municipal district Rincon, department of Aguadilla. Population 770.

Cubeu; barrio in municipal district Loiza, department of Bayamon. Population 1,225.

Cubui, Rio; a small branch of Rio Blanco, in the east.

Cucurachas; islets off northeast point.

Cucharas, Punta; point on southern coast.

Cuchilla; barrio in municipal district Moca, department of Aguadilla. Population 1,552.

Cuchilla; barrio in municipal district Morovis, department of Arecibo. Population 716.

Cuchilla Brava; mountains in western part of Ponce department.

Cuchillas; barrio in municipal district Corozal, department of Bayamon. Population 585.

Cuevas; barrio in municipal district Peñuelas, department of Ponce.

Cuevas; barrio in municipal district Trujillo Alto, department of Bayamon. Population 688.

Cueva, Isla; islet off southwest coast.

Cuevas, Cerro de las; hills in department of Ponce.

Culebra, Isla; island east of Porto Rico, constituting a barrio of that name in the municipal district of Vieques, department of Humacao. Population 704.

Culebras Alto; barrio in municipal district Cayey, department of Guayama.

Culebras Bajo; barrio in municipal district Cayey, department of Guayama.

Culebrinas; barrio in municipal district San Sebastian, department of Aguadilla.

Culebrinas, Rio; a river flowing from the mountains to the sea on the northwest coast.

Cupey; barrio in municipal district Rio Piedras, department of Bayamon. Population 1,834.

[illegible] **Punta**; northeast point of island.

[illegible] district Aibonito, department of Ponce. Population [illegible]

[illegible] trict Coamo, department of Ponce.

Cuyon, Rio de; a branch of Rio de Coamo, in the south.

Daguado, Rio; a small stream in the eastern part of the island.

Daguao; barrio in municipal district Fajardo, department of Humacao.

Daguao; barrio in municipal district Naguabo, department of Humacao. Population 756.

Daguey; barrio in municipal district Añasco, department of Mayaguez.

Dajaos; barrio in municipal district Bayamon, department of Bayamon. Population 851.

Damian Abajo; barrio in municipal district Barros, department of Ponce. Population 922.

Damian Arriba; barrio in municipal district Barros, department of Ponce. Population 839.

Demajagua; barrio in municipal district Fajardo, department of Humacao.

Descalabrado; barrio in municipal district Santa Isabel, department of Ponce.

Descalabrada, Rio; a small stream in the southern part of the island.

Descause, Alto del; a summit in the eastern part of Mayaguez department.

Domingo Ruiz; barrio in municipal district Arecibo, department of Arecibo. Population 931.

Dominguito; barrio in municipal district Arecibo, department of Arecibo. Population 1,093.

Doña Elena; barrio in municipal district Comerio, department of Guayama. Population 1,460.

Don Alonso; barrio in municipal district Utuado, department of Arecibo. Population 1,610.

Dorado; municipal district in department of Bayamon. Area 19 square miles. Population 3,804.

Dorado; post-office in department of Bayamon.

Dos Bocas; barrio in municipal district Corozal, department of Bayamon. Population 909.

Dos Bocas; barrio in municipal district Trujillo Alto, department of Bayamon. Population 369.

Duey; barrio in municipal district Yauco, department of Ponce. Population 1,264.

Duey Alto; barrio in municipal district San German, department of Mayaguez.

Duey Bajo; barrio in municipal district San German, department of Mayaguez. Population 943.

Duey, Rio; a stream in the southern part of the island, flowing to the sea.

Duey, Rio; a right-hand branch of Rio Guanajibo, in the western part of the island.

Duque; barrio in municipal district Naguabo, department of Humacao. Population 1,238.

El Puerto; the harbor of Isabela, on northwest coast.

Emajagua; barrio in municipal district Maunabo, department of Humacao. Population 828.

Emajagual; barrio in municipal district Juana Diaz, department of Ponce.

Encarnacion; barrio in municipal district Peñuelas, department of Ponce.

Enea; barrio in municipal district San Sebastian, department of Aguadilla.

Ensenada; barrio in municipal district Rincon, department of Aguadilla. Population 674.

Ensenada, Punta la; point on west coast.

Equilarte, Punta; point on south coast, near Arroyo.

Ermita; barrio in municipal district Coamo, department of Ponce. Population 1,400.

Escambron, Punta del; point on north coast, near San Juan Harbor.

Esperanza; barrio in municipal district Arecibo, department Arecibo. Population 2,843.

Espinal; barrio in municipal district Aguada, department of Aguadilla.

Espino; barrio in municipal district Añasco, department of Mayaguez.

Espino; barrio in municipal district Lares, department of Aguadilla. Population 1,148.

Espino; barrio in municipal district Las Marias, department of Mayaguez.

Espino; barrio in municipal district San Lorenzo, department of Guayama. Population 1,522.

Espinosa; barrio in municipal district Dorado, department of Bayamon. Population 737.

Espinosa; barrio in municipal district Vega Alta, department of Bayamon. Population 781.

Espiritu Santo, Rio; a branch of Rio Grande, in the northeastern part of the island.

Este; barrio in municipal district Coamo, department of Ponce.

Factor; barrio in municipal district Arecibo, department of Arecibo. Population 1,072.

Fajardo; municipal district in department of Humacao. Area 81 square miles. Population 16,782.

Fajardo; city and post-office in department of Humacao, situated near coast. Population 3,414.

Fajardo; barrio in municipal district Fajardo, department of Humacao. Population 3,414.

Fajardo, Punta de; point on eastern coast off Fajardo.

Fajardo, Rio de; a small stream in the northeast.

Fama, Punta; point on southern coast near Santa Isabel.

Farallon; barrio in municipal district Cayey, department of Guayama.

Farallon, Cerro; hills near Cayey.

Felicia; barrio in municipal district Santa Isabel, department of Ponce.

Feliciana, Punta; point on southeast coast.

Figuera, Punta; point on eastern coast.

Figuerita, Punta; point on eastern coast.

Flamencas, Punta; point on southern coast near Guanica.

Florencio; barrio in municipal district Fijardo, department of Humacao.

Flores, Rio; a right-hand branch of Rio Guanajibo, in the southeast part of the island.

Florida; post village in department of Arecibo.

Florida; barrio in municipal district San Lorenzo, department of Guayama. Population 807.

Florida; barrio in municipal district Vieques, department of Humacao.

Florida Adentro; barrio in municipal district Barceloneta, department of Arecibo. Population 2,002.

Florida Afuera; barrio in municipal district Barceloneta, department of Arecibo, Population 3,579.

Frailes; barrio in municipal district of Rio Piedras, department of Bayamon. Population 562.

Frailes; barrio in municipal district Yauco, department of Ponce. Population 919.

Frances, Cerro; mountains in department of Humacao.

Franquez; barrio in municipal district Morovis, department of Arecibo. Population 695.

Fronton; barrio in municipal district Ciales, department of Arecibo. Population 3,706.

Fuerte, Punta del; point on west coast near Cabo Rojo.

Furnias; barrio in municipal district Las Marias, department of Mayaguez.

Galatea; barrio in municipal district Toa Alta, department of Bayamon. Population 606.

Galateo Alto; barrio in municipal district Isabela, department of Aguadilla. Population 1,063.

Galeteo Bajo; barrio in municipal district Isabela, department of Aguadilla. Population 705.

Garrochales; barrio in municipal district Arecibo, department of Arecibo. Population 950.

Garrochales; barrio in municipal district Barceloneta, department of Arecibo. Population 1,058.

Garzas; barrio in municipal district Adjuntas, department of Ponce. Population 1,425.

Garzas, Isla de la; small island off north coast near mouth of Rio Cibuco.

Gata, Punta de la; point on north coast near Quebradillas.

Gatas, Isla; islet off south coast near Ponce.

Gato; barrio in municipal district Barros, department of Ponce. Population 876.

Golay, Punta; point at entrance to Guayanilla Harbor on southern coast.

Gorda, Punta; point on northwest coast.

Gorda, Punta; point on east coast.

Gordo, Cerro; Mountains near Hato Grande.

Grande, Rio; a small steam flowing to the sea on the northwest coast.

Grande, Rio; a small stream in the northeastern part of the island.

Guaba, Rio de la; a left-hand branch of Rio Blanco in the northwestern part of the island.

Guacio; barrio in municipal district San Sebastian, department of Aguadilla. Population 562.

Guadiana; barrio in the municipal district Naranjito, department of Bayamon. Population 1,006.

Guajataca; barrio in municipal district Quebradillas, department of Arecibo. Population 666.

Guajataca; barrio in municipal district San Sebastian, department of Aguadilla.

Guajataca, Rio; river, heading above Lares and flowing north to its mouth near Quebradillas on north coast. Length 13 miles.

Guama; barrio in municipal district San German, department of Mayaguez. Population 1,188.

Guamani; barrio in municipal district Guayama, department of Guayama. Population 1,360.

Guamani, Rio; a small stream in the southern part of the island.

Guanabanas; barrio in municipal district Aguada, department of Aguadilla.

Guanabo, Rio; a right-hand branch of Bayamon River in Bayamon department.

Guanaguilla; barrio in municipal district Aguada, department of Aguadilla.

Guanajibo; barrio in municipal district Cabo Rojo, department of Mayaguez. Population 1,074.

Guanajibo; barrio in municipal district Hormigueros, department of Mayaguez.

Guanajibo; barrio in municipal district Mayaguez, department of Mayaguez. Population 1,032.

Guanajibo, Rio; a river flowing from the mountains westward to the west coast. Length 23 miles.

Guananes; **Rio**, a river in the southeastern part of the island.

Guanaquilla, Punta; point on west coast.

Guancha, Punta; point on south coast, near Ponce.

Guanica; post village in department of Ponce.

Guanica; barrio in municipal district Yauco, department of Ponce. Population 2,700.

Guanica, Laguna de; a marshy lake in the southwestern part of the island.

Guanica, Puerto; harbor on south coast.

Guaonico; barrio in municipal district Utuado, department of Arecibo. Population 771.

Guaraguaos; barrio in municipal district Ponce, department of Ponce. Population 1,771.

Guaraguaos Abajo; barrio in municipal district Bayamon, department of Bayamon. Population 837.

Guaraguaos Arriba; barrio in municipal district Bayamon, department of Bayamon. Population 681.

Guaraguaos de Guaynabo; barrio in municipal district Bayamon, department of Bayamon. Population 763.

Guardarraya; barrio in municipal district Patillas, department of Humacao. Population 1,013.

Guasimas; barrio in municipal district Arroyo, department of Guayama.

Guatemala; barrio in municipal district San Sebastian, department of Aguadilla.

Guatemala, Rio; a right-hand branch of Rio Culebrinas; in the northwest.

Guavate; barrio in municipal district Cayey, department of Guayama.

Guayabal; barrio in municipal district Juana Diaz, department of Ponce. Population 2,034.

Guayabo; barrio in municipal district Aguada, department of Aguadilla.

Guayabo Dulce; barrio in municipal district Adjuntas, department of Ponce. Population 1,055.

Guayabos; barrio in municipal district Isabela, department of Aguadilla. Population 818.

Guayabota; barrio in municipal district Yabucoa, department of Humacao. Population 904.

Guayabote; barrio in municipal district Patillas, department of Humacao.

Guayabota, Cerro; hills in Humacao department.

Guayacan; barrio in municipal district Fajardo, department of Humacao.

Guayacan, Punta; point on island off southwest coast.

Guayama; a department situated in the southeastern part of the island. Its area is 561 square miles, and its population 111,986, showing a density of 200 inhabitants per square mile. As to race, the population was divided in the proportions of 50.7 per cent white and 49.3 per cent colored, the two races being nearly equal in number. Only 14 per cent of the area of the department was under cultivation, and of this cultivated area 38 per cent was planted in coffee and 16 per cent in sugar cane. Of the total farm area 79 per cent was owned by its occupants, and but 21 per cent rented.

Guayama; municipal district in department of Guayama. Area 64 square miles. Population 12,749.

Guayama; coast city and post-office in department of Guayma. Population 5,334.

Guayama; bay on south coast.

Guayanes; barrio in municipal district Yabucoa, department of Humacao. Population 801.

Guayanilla; municipal district in department of Ponce. Area 47 square miles. Population 9,540.

Guayanilla; post village in department of Ponce.

Guayanilla, Ensenada de; harbor on southern coast.

Guayanilla, Rio; a stream in the southern part of the island flowing into the sea at Guayanilla.

Guaynabo; barrio in municipal district Bayamon, department of Bayamon. Population 465.

Guayo; barrio in municipal district Adjuntas, department of Ponce.

Guayo, Cerro del; mountains in northern part of Ponce department.

Guerrero; barrio in municipal district Aguadilla, department of Aguadilla. Population 638.

Guerrero; barrio in municipal district Isabela, department of Aguadilla. Population 753.

Guilarte; barrio in municipal district Adjuntas, department of Ponce. Population 1,019.

Guilarte, Rio de; a head branch of Rio Blanco in the northwest.

Guilarte, Cerro; mountains in the western part of Ponce department. Altitude 3,608 feet.

Gurabo; municipal district in department of Guayama. Area 28 square miles. Population 8,700.

Gurabo; interior city and post-office in department of Guayama. Population 1,309.

Gurabo Abajo; barrio in municipal district Juncos, department of Guayama.

Gurabo Arriba; barrio in municipal district Juncos, department of Guayama.

Gurabo, Rio; a left-hand branch of Loiza River.

Gurabo, Rio; a right-hand branch of Loiza River.

Guzman Abajo; barrio in municipal district Rio Grande, department of Bayamon. Population 1,378.

Guzman Arriba; barrio in municipal district Rio Grande, department of Bayamon. Population 1,047.

Habana, Boca; entrance to Rio de la Plata on north coast, near Dorado.

Hatillo; municipal district in department of Arecibo. Area 39 square miles. Population 10,449.

Hatillo; post village in department of Arecibo.

Hatillo; barrio in municipal district Añasco, department of Mayaguez.

Hato; barrio in municipal district San Lorenzo, department of Guayama. Population 1,028.

Hato Abajo; barrio in municipal district Arecibo, department of Arecibo. Population 1,869.

Hato Arriba; barrio in municipal district Arecibo, department of Arecibo. Population 1,751.

Hato Arriba; bario in municipal district San Sebastian, department of Aguadilla. Population 663.

Hato Nuevo; barrio in municipal district Gurabo, department of Guayama. Population 1,361.

Hato Nueva; barrio in municipal district Rio Piedras, department of Bayamon. Population 683.

Hato-Puerco; barrio in municipal district Loiza, department of Bayamon. Population 3,139.

Hato-Puerco Abajo; barrio in municipal district Juana Diaz, department of Ponce. Population 991.

Hato-Puerco Arriba; barrio in municipal district Juana Diaz, department of Ponce. Population 1,496.

Hato Rey; barrio in municipal district Rio Piedras, department of Bayamon. Population 1,324.

Hato Teja; barrio in municipal district Bayamon, department of Bayamon. Population 1,358.

Hato Viejo; barrio in municipal district Arecibo, department of Arecibo. Population 2,588.

Hato Viejo; barrio in municipal district Ciales, department of Arecibo. Population 1,800.

Hato Viejo; barrio in municipal district Rio Grande, department of Bayamon. Population 473.

Helechal; barrio in municipal district Barranquitas, department of Ponce. Population 1,485.

Herrera; barrio in municipal district Rio Grande, department of Bayamon. Population 221.

Herrera, Rio; a small stream in the northeastern part of the island.

Hicacos; island off the northeast coast.

Hicacos, Cerro; mountains in Humacao department.

Higuey; barrio in municipal district Aguadilla, department of Aguadilla.

Higuillar; barrio in municipal district Dorado, department of Bayamon. Population 820.

Hoconuco Alto; barrio in municipal district San German, department of Mayaguez. Population 943.

Hoconuco Bajo: barrio in municipal district San German, department of Mayaguez. Population 1,047.

Hoconuco, Rio; a right-hand branch of Rio Guanajibo, in the western part of the island.

Honda Ensenada; harbor on the east coast, near Ceiba.

Hondo, Cayo; islet off the southern coast, near Guanica.

Hondo, Rio; a small stream flowing to the sea in the northwestern part of the island.

Hondura; barrio in municipal district Cidra, department of Guayama.

Honduras; barrio in municipal district Barranquitas, department of Ponce. Population 862.

Hormigueros; municipal district in department of Mayaguez. Area 12 square miles. Population 3,215.

Hormigueros; barrio in municipal district Hormigueros, department of Mayaguez.

Hoya Mala; barrio in municipal district San Sebastian, department of Aguadilla. Population 1,215.

Hoyo-Mulas; barrio in municipal district Carolina, department of Bayamon. Population 1,245.

Hucares; barrio in municipal district Naguabo, department of Humacao. Population 826.

Humacao: a department occupying most of the eastern end of the island. Its area is 329 square miles, and its population 88,501, showing a density of population of 214 per square mile. As to race, the population is divided in proportion of 46.1 per cent white and 53.9 per cent colored, this department having a larger proportion of colored than any other. Of the total area only 15 per cent was under cultivation. Of this cultivated area 53 per cent, or considerably more than one-half, was planted in sugar cane, and 9 per cent only in coffee. Of the total farm area 84 per cent was owned by its occupants, the remaining 16 per cent being rented.

Humacao; municipal district in department of Humacao. Area 38 square miles. Population 14,313.

Humacao; city and post-office in department of Humacao, situated near coast. Population 4,428.

Humacao, Rio de; a small stream in the southeastern part of the island.

Humala, Rio: a small right-hand branch of Rio Blanco, in the northwestern part of the island.

Humatas; barrio in municipal district Añasco, department of Mayaguez.

Iglesia; barrio in municipal district Aguadilla, department of Aguadilla.

Inabon, Rio: a small stream in the southern part of the island.

Indiera Alta; barrio in municipal district Maricao, department of Mayaguez. Population 1,145.

Indiera Baja; barrio in municipal district Maricao, department of Mayaguez. Population 933.

Indiera Frios; barrio in municipal district Maricao, department of Mayaguez. Population 1,165.

Indiera, Sierra de la; short range of mountains in eastern part of Mayaguez department.

Indio, Punta del; point on eastern coast.

Indios; barrio in municipal district Guayanilla, department of Ponce.

Ingenio, Rio del; a small stream in the southeastern part of the island.

Inglesia, Punta de la; point on north coast near Loiza.

Insua Alta; barrio in municipal district Yauco, department of Ponce.

Insua Baja; barrio in municipal district Yauco, department of Ponce. Population 811.

Isabela; municipal district in department of Aguadilla. Area 53 square miles. Population 14,888.

Isabela; post village in department of Aguadilla.

Isabel de Cabras, Punta; point on south coast.

Isolete; barrio in municipal district Arecibo, department of Arecibo. Population 2,498.

Isolina; post village in department of Arecibo.

Jacaboa; barrio in municipal district Patillas, department of Humacao.

Jacabos, Rio; a small stream in the southeastern part of the island.

Jacaguas; barrio in the municipal district Juana Diaz, department of Ponce.

Jacaguas, Rio; a river heading in the divide and flowing to the south coast. Length 20 miles.

Jacana; barrio in municipal district Yabucoa, department of Humacao. Population 1,101.

Jacana; barrio in municipal district Yauco, department of Ponce.

Jacome Alto: barrio in municipal district Cayey, department of Guayama. Population 1,246.

Jacome Bajo: barrio in municipal district Cayey, department of Guayama.

Jagua; barrio in municipal district Ciales, department Arecibo. Population 1,264.

Jagua; barrio in municipal district Guayanilla, department of Ponce.

Jagua; barrio in municipal district Gurabo, department of Guayama. Population 868.

Jagua; barrio in municipal district Peñuelas, department of Ponce. Population 971.

Jagual; barrio in municipal district Gurabo, department of Guayama.

Jagual; barrio in municipal district Patillas, department of Humacao.

Jagual: barrio in municipal district San Lorenzo, department of Guayama. Population 1,024.

Jagua-Pasto: barrio in municipal district Guayanilla, department of Ponce.

Jaguey: barrio in municipal district Rincon, department of Aguadilla. Population 576.

Jaguey; barrio in municipal district Aguada, department of Aguadilla.

Jagueyes; barrio in municipal district Aguas Buenas, department of Guayama.

Jaguita; barrio in municipal district Hormigueros, department of Mayaguez.

Jajome, Sierra de; mountains in department of Guayama.

Jajome, Rio; a branch of Rio de la Lapa, in the southern part of the island.

Jauca, Nos. 1 and 2; barrios in municipal district, Santa Isabel, department of Ponce.

Jayuya; post village in department of Arecibo.

Jayuya Abajo; barrio in municipal district Utuado, department of Arecibo. Population 3,597.

Jayuya Arriba; barrio in municipal district Utuado, department of Arecibo. Population 5,700.

Jayuya, Sierra del; mountains in southeastern part of department of Arecibo.

Jihuero, Punta del; point on west coast.

Jimines; barrio in municipal district Rio Grande, department of Bayamon. Population 1,778.

Jobos; barrio in municipal district Guayama, department of Guayama. Population 1,186.

Jobos; barrio in municipal district Isabela, department of Aguadilla. Population 1,551.

Jobos, Puerto de; harbor on south coast.

Jollin, Cerro; hills in department of Ponce.

Juana Dias; municipal district in department of Ponce. Area 105 square miles. Population 27,896.

Juana Dias; city and post-office in department of Ponce. Population 2,246.

Juan Alonso; barrio in municipal district Mayaguez, department of Mayaguez. Population 1,041.

Juan Asencio; barrio in municipal district Aguas Buenas, department of Guayama. Population 1,029.

Juan Gonzales; barrio in municipal district Adjuntas, department of Ponce.

Juani Quebrada; ravine on north coast, near Quebradillas.

Juan Martin; barrio in municipal district Yabucoa, department of Humacao. Population 1,473.

Juan Martines; barrio in municipal district Fajardo, department of Humacao.

Juan Sanches; barrio in municipal district Bayamon, department of Bayamon. Population 926.

Jueyes, Rio; a small stream in the southern part of the island.

Juncal; barrio in municipal district San Sebastian, department of Aguadilla. Population 761.

Juncos; municipal district in department of Guayama. Area 38 square miles. Population 8,429.

Juncos; interior city and post-office in department of Guayama. Population 2,026.

Lagunas; barrio in municipal district Aguada, department of Aguadilla. Population 753.

Lajas; municipal district in department of Mayaguez. Area 48 square miles. Population 8,789.

Lajas; interior city and post-office in department of Mayaguez. Population 1,385.

Lajas, Rio; a left-hand tributary of Rio Blanco in the northwest.

Lajas Arriba; barrio in municipal district Lajas, department of Mayaguez. Population 1,152.

Lapa; barrio in municipal district Cayey, department of Guayama.

Lapa; barrio in municipal district Salinas, department of Guayama. Population 1,019.

Lapa, Rio de la; a stream flowing southward from the divide to the sea at Salinas.

Lares; municipal district in department of Aguadilla. Area 48 square miles. Population 20,883.

Lares; interior city and post-office in department of Aguadilla. Population 3,714.

Lares; barrio in municipal district Lares, department of Aguadilla. Population 1,954.

Las Marias; municipal district in department of Mayaguez. Area 39 square miles. Population 11,279.

Las Marias; post village in department of Mayaguez.

Las Palmas; barrio in municipal district Utuado, department of Arecibo. Population 647.

Latorre; barrio in municipal district Lares, department of Aguadilla. Population 2,008.

Latorre, Cerro: hills in southeastern part of department of Mayaguez.

Laurel: barrio in municipal district Arroyo, department of Guayama. Population 1,333.

Lavadero; barrio in municipal district Hormigueros, department of Mayaguez.

Leguisamo; barrio in municipal district Mayaguez, department of Mayaguez. Population 1,228.

Leniani, Rio: a head branch of Rio Blanco in the northwestern part of the island.

Lenia, Punta de la; point on southeast coast.

Limani; barrio in municipal district Adjuntas, department of Ponce. Population 1,075.

Limon; barrio in municipal district Mayaguez, department of Mayaguez. Population 870.

Limon: barrio in municipal district Utuado, department of Arecibo. Population 857.

Limon, Altos del; mountains in Mayaguez department.

Limon, Rio; a right-hand branch of Arecibo River in department of Arecibo.

Limones; barrio in municipal district Yabucoa, department of Humacao. Population 1,139.

Limones, Rio; a small stream in the southeastern part of the island.

Lirios; barrio in municipal district Juncos, department of Guayama. Population 815.

Lizas; barrio in municipal district Maunabo, department of Humacao.

Llanadas; barrio in municipal district Isabela, department of Aguadilla. Population 1,564.

Llana, Sierra; mountains in Mayaguez department.

Llano; barrio in municipal district Aibonito, department of Ponce.

Llano: barrio in municipal district Guayanilla, department of Ponce.

Llanos: barrio in municipal district Coamo, department of Ponce. Population 1,064.

Llanos; barrio in municipal district Lajas, department of Mayaguez.

Llanos Costa: barrio in municipal district Cabo Rojo, department of Mayaguez. Population 867.

Llanos Tuna; barrio in municipal district Cabo Rojo, department of Mayaguez. Population 2,976.

Llaurel, Sierra del; hills in department of Guayama.

Llave: barrio in municipal district Vieques, department of Humacao, on Isla de Vieques.

Loina: barrio in municipal district Naranjito, department of Bayamon. Population 994.

Loiza; post village in department of Bayamon.

Loiza; municipal district in department of Bayamon. Area 60 square miles. Population 12,522.

Loiza, Rio Grande de; river in northeastern part of the island heading in the main mountain range and flowing generally northeast to its mouth at Loiza. Length 40 miles.

Lomas; barrio in municipal district Juana Diaz, department of Ponce.

Lomas; barrio in municipal district Loiza, department of Bayamon. Population 1,614.

Los Cearos, Quebrada; small stream in northern part of Aguadilla department.

Los Farallones; small islands off north coast, near Quebradillas.

Luquillo; post village in department of Humacao.

Luquilla, Sierra de; short range in northeastern part of island.

Mabille, Rio; a right-hand branch of Cibuco River, in Bayamon department.

Mabu; barrio in municipal district Humacao, department of Humacao.

Macana; barrio in municipal district Guayanilla, department of Ponce.

Macana; barrio in municipal district Peñuelas, department of Ponce. Population 1,025.

Macana, Rio; a small stream in the southern part of the island.

Machete; barrio in municipal district Guayama, department of Guayama. Population 868.

Macho, Ensenada; open roadstead on east coast.

Machose; barrio in municipal district Fajardo, department of Humacao.

Machuchal; barrio in municipal district Sabana Grande, department of Mayaguez. Population 999.

Machuelo Abajo; barrio in municipal district Ponce, department of Ponce. Population 1,898.

Machuelo Arriba; barrio in municipal district Ponce, department of Ponce. Population 1,418.

Magas; barrio in municipal district Guayanilla, department of Ponce.

Magos; barrio in municipal district San Sebastian, department of Aguadilla.

Magoyo, Cerro; hills in southeastern part of department of Arecibo.

Maguayo; barrio in municipal district Dorado, department of Bayamon. Population 764.

Magueyes; barrio in municipal district Corozal, department of Bayamon. Population 849.

Magueyes; barrio in municipal district Ponce, deparrtment of Ponce. Population 1,171.

Magueyes, Isla; islet off southwest coast.

Maizales; barrio in municipal district Naguabo, department of Humacao. Population 1,060.

Majagua, Ensenada; open roadstead on east coast.

Mala Pascua, Cabo; cape on southeast coast near Maunabo.

Malesas Alta; barrio in municipal district Aguadilla, department of Aguadilla. Population 784.

Malesas Baja; barrio in municipal district Aguadilla, department of Aguadilla. Population 905.

Malezas; barrio in municipal district Mayaguez, department of Mayaguez.

Maldonado, Punta; point on north coast, east of San Juan.

Malo, Cerro; mountains in western part of department of Ponce.

Mal-paso; barrio in municipal district Aguada, department of Aguadilla.

Mambiche; barrio in municipal district Humacao, department of Humacao.

Mamey; barrio in municipal district Gurabo, department of Guayama. Population 680.

Mamey; barrio in municipal district Juncos, department of Guayama.

Mamey; barrio in municipal district Patillas, department of Humacao.

Mamey; barrio in municipal district Rio Piedras, department of Bayamon. Population 636.

Mamey; barrio in municipal district Aguada, department of Aguadilla. Population 558.

Mameyal; barrio in municipal district Dorado, department of Bayamon. Population 169.

Mamey, Cuchilla del; hills near Manuabo.

Mameyes; post village in department of Bayamon.

Mameyes; barrio in municipal district Rio Grande, department of Bayamon. Population 2,070.

Mameyes; barrio in municipal district Utuado, department of Arecibo. Population 4,268.

Mameyes, Punta; point on north coast near Dorado.

Mameyes, Rio; small stream in the northeastern part of the island.

Manati; municipal district in department of Arecibo. Area 51 square miles. Population 13,989.

Manati; city and post-office in department of Arecibo, situated near coast. Population 4,494.

Manati, Punta de; point at mouth of Manati River on north coast.

Manati, Rio; a river heading in the main mountain range and flowing north to the coast near Barceloneta. Length following up the Bauta branch, 29 miles.

Manguilla, Punta; point on south coast near Guanica.

Manquitas, Isla de las; islet off southern coast, west of Ponce.

Manuel, Pozo de; harbor on north coast, near Hatillo.

Maracuto, Rio; a right-hand branch of Loiza River.

Maraguez; barrio in municipal district Ponce, department of Ponce. Population 1,756.

Maravilla; barrio in municipal district Las Marias, department of Mayaguez.

Maravillas, Cerros; mountains in northern part of department of Ponce.

Maresua; barrio in municipal district San German, department of Mayaguez.

Maria; barrio in municipal district Corozal, department of Bayamon. Population 1,133.

Maria; barrio in municipal district Moca, department of Aguadilla. Population 1,062.

Mariana; barrio in municipal district Naguabo, department of Humacao. Population 1,280.

Mariana, Cerro; hills near Patillas.

Marianao; barrio in municipal district Humacao, department of Humacao. Population 1,296.

Marias; barrio in municipal district Aguada, department of Aguadilla. Population 746.

Marias; barrio in municipal district Añasco, department of Mayaguez.

Marias, Punta de las; point on north coast, east of San Juan.

Maricao; municipal district in department of Mayaguez. Area 41 square miles. Population 8,312.

Maricao; interior city and post-office in department of Mayaguez. Population 1,179.

Maricao; barrio in municipal district Vega Alta, department of Bayamon. Population 741.

Maricao Afuera; barrio in municipal district Maricao, department of Mayaguez. Population 1,390.

Maricayo, Punta; point on north coast, in department of Arecibo.

Marina; barrio in municipal district San Juan, department of Bayamon. Population 2,144.

Marina Meridional; barrio in municipal district Mayaguez, department of Mayaguez. Population 1,611.

Marina Septentrional; barrio in municipal district Mayaguez, department of Mayaguez. Population 2,934.

Maronguey, Punta; point on northern shore, east of Arecibo.

Martin Gonzales; barrio in municipal district Carolina, department of Bayamon. Population 708.

Marueño; barrio in municipal district Ponce, department of Ponce. Population 1,105.

Marunguey, Punta; point on east coast, near Fajardo.

Marungueyes, Playas; beach on north shore, east of Arecibo.

Masas; barrio in municipal district Gurabo, department of Guayama.

Mata de Caña; barrio in municipal district Barros, department of Ponce.

Mata de Platano; barrio in municipal district Rio Grande, department of Bayamon. Population 717.

Matagorda, Punta de; point on south coast.

Mataredonda, Punta; point on east coast.

Matei, Isla; island off south coast.

Maton; barrio in municipal district Patillas, department of Humacao.

Maton Abajo; barrio in municipal district Cayey, department of Guayama.

Maton Arriba; barrio in municipal district Cayey, department of Guayama.

Matrulla, Rio; a branch of Manati River in department of Arecibo.

Matuyas Alto; barrio in municipal district Maunabo, department of Humacao.

Matuyas Bajo; barrio in municipal district Maunabo, department of Humacao.

Maunabo; municipal district in department of Humacao. Area 19 square miles. Population 6,221.

Maunabo; city and post-office in department of Humacao, situated near coast. Population 1,277.

Maunabo, Puerto de; harbor on southeast coast.

Maunabo, Rio; A small stream in the southeast part of the island.

Mayaguez; a department occupying most of the western end of the island. Its area is 395 square miles, and its population 127,566. The density of population is 313 per square mile. As to race, the population is divided in the proportions of 64.3 per cent white and 35.7 per cent colored. Of the total area, 31 per cent was under cultivation. Of this cultivated area not less than 54 per cent was planted in coffee trees, and but 12 per cent in sugar cane. Of the total farm area, 94 per cent was owned by its occupants, and but 6 per cent was rented.

Mayaguez; municipal district in department of Mayaguez. Area 48 square miles. Population 35,700.

Mayaguez; coast city and post-office in department of Mayaguez. Population 15,187.

Mayaguez Arriba; barrio in municipal district Mayaguez, department of Mayaguez. Population 2,187.

Media Luna; barrio in municipal district Toa Baja, department of Bayamon. Population 598.

Mediania; barrio in municipal district Loiza, department of Bayamon. Population 2,296.

Medio Mundo, Isla; island off eastern coast, near Ceiba.

Medio Mundo, Punta; point on island of same name off east coast.

Melones, Punta; point on southwest coast.

Membrillo; barrio in municipal district Camuy, department of Arecibo. Population 769.

Mercado; barrio in municipal district San Juan, department of Bayamon. Population 2,038.

Mesa, Cuchilla de la; hills in department of Ponce.

Millan, Cerro; hills near Yabucoa.

Mina, Cerro de la; mountains in Humacao department.

Minas, Cerro de las; hills near Coamo.

Minillas; barrio in municipal district Bayamon, department of Bayamon. Population 1,000.

Minillas; barrio in municipal district San German, department of Mayaguez. Population 1,657.

Miquillo, Punta; point on north coast near Rio Grande.

Mirabeles; barrio in municipal district San Sebastian, department of Aguadilla. Population 404.

Miradero; barrio in municipal district Cabo Rojo, department of Mayaguez. Population 2,011.

Miradero; barrio in municipal district Mayaguez, department of Mayaguez. Population 1,268.

Miraflores; barrio in municipal district Arecibo, department of Arecibo. Population 1,416.

Miraflores, Isla; island in San Juan Harbor on north coast.

Mirasol; barrio in municipal district Lares, department of Aguadilla. Population 1,027.

Moca; municipal district in department of Aguadilla. Area 26 square miles. Population 12,410.

Moca; interior city in department of Aguadilla. Population 1,470.

Moja Casabe, Punta; point on southwestern coast.

Molino, Punta del; point on southwestern coast.

Mona, Isla; island in the Windward Passage, west of Porto Rico. A barrio in municipal district Mayaguez, department of Mayaguez. Population 6.

Monacillo; barrio in municipal district Rio Piedras, department of Bayamon. Population 1,295.

Montana; barrio in municipal district Aguadilla, department of Aguadilla. Population 633.

Monte Grande; barrio in municipal district Cabo Rojo, department of Mayaguez. Population 2,019.

Monte Llano; barrio in municipal district Cayey, department of Guayama.

Monte Llano; barrio in municipal district Cidra, department of Guayama.

Monte Llano; barrio in municipal district Morovis, department of Arecibo. Population 466.

Montes Llanos; barrio in municipal district Ponce, department of Ponce. Population 964.

Montes Llanos, Sierra de; mountains in department of Ponce.

Montones Abajo; barrio in municipal district Piedras, department of Humacao. Population 899.

Montones Arriba; barrio in municipal district Piedras, department of Humacao. Population 937.

Montoso; barrio in municipal district Maricao, department of Mayaguez. Population 1,146.

Montoso, Cerro; mountains in the eastern part of Mayaguez department.

Mora; barrio in municipal district Isabela, department of Aguadilla. Population 972.

Morales, Cerro; hills in southeastern part of department of Arecibo.

Morovis; municipal district in department of Arecibo. Area 66 square miles. Population 11,309.

Morovis; interior city and post-office in department of Arecibo. Population 1,064.

Morovis Norte; Barrio in municipal district Morovis, department of Arecibo. Population 821.

Morovis Sur; barrio in municipal district Morovis, department of Arecibo. Population 487.

Mosquito; barrio in municipal district Vieques, department of Humacao.

Mucarabonaz; barrio in municipal district Toa Alta, department of Bayamon. Population 954.

Muertos, Cerro de los; hills in the department of Ponce, near Coamo.

Mulas; barrio in municipal district Aguas Buenas, department of Guayama.

Mulas; barrio in municipal district Patillas, department of Humacao. Population 823.

Mulita; barrio in municipal district Aguas Buenas, department of Guayama. Population 752.

Naguabo; municipal district in department of Humacao. Area 39 square miles. Population 10,873.

Naguabo; coast city and post-office in department of Humacao. Population 1,812.

Naguabo, Puerto de; harbor on southeast coast.

Naranjales; barrio in municipal district Las Marías, department of Mayaguez.

Naranjales; barrio in municipal district Mayaguez, department of Mayaguez.

Naranjal, Sierra de; mountains in eastern part of Mayaguez district.

Naranjito; municipal district in department of Bayamon. Area 35 square miles. Population 8,101.

Naranjito; post village in department of Bayamon.

Naranjito; barrio in municipal district Hatillo, department of Arecibo. Population 966.

Naranjito, Rio; a left-hand branch of Río de la Plata, in Bayamon department.

Naranjitos, Rio; a right-hand tributary of Arecibo River, in Arecibo department.

Naranjo; barrio in municipal district Comerio, department of Guayama. Population 815.

Naranjo; barrio in municipal district Fajardo, department of Humacao.

Naranjo; barrio in municipal district Moca, department of Aguadilla. Population 966.

Naranjo; barrio in municipal district Yauco, department of Ponce. Population 1,358.

Naranjo; barrio in municipal district Aguada, department of Aguadilla. Population 923.

Navajas, Cerro; hills in southeastern part of department of Arecibo.

Navarro; barrio in municipal district Gurabo, department of Guayama.

Negros; barrio in municipal district Corozal, department of Bayamon. Population 818.

Negros, Rio de los; a right-hand tributary to Cibucu River, in Bayamon department.

Norzagaray; barrio in municipal district San Sebastian, department of Aguadilla.

Novillo; barrio in municipal district Vega Alta, department of Bayamon. Population 982.

Novillo, Cerro; mountains in northwestern part of Ponce department.

Nuevo; barrio in municipal district Aguadilla, department of Aguadilla. Population 1,537.

Nuevo; barrio in municipal district Bayamon, department of Bayamon. Population 1,123.

Nuevo; barrio in municipal district Naranjito, department of Bayamon. Population 1,081.

Nuevo, Puerto; open roadstead on north coast, near Vega Baja.

Obispo, Isla; island off east coast.

Oeste; barrio in municipal district Coamo, department of Ponce.

Orocovis; barrio in municipal district Barros, department of Ponce.

Ortiz; barrio in municipal district Toa Alta, department of Bayamon. Population 948.

Ostiones, Punta; point on west coast.

Ovejas; barrio in municipal district Anasco, department of Mayaguez.

Padilla; barrio in municipal district Corozal, department of Bayamon. Population 840.

Padre Toro, Cerro; hills in department of Ponce.

Pajaros; barrio in municipal district Bayamon, department of Bayamon. Population 1,492.

Pajuil; barrio in municipal district Hatillo, department of Arecibo. Population 130.

Palma; barrio in municipal district Salinas, department of Guayama.

Palma, Punta; point on northwest coast.

Palma, Quebrada la; Ravine on northern coast, near Quebradillas.

Palma Escrita; barrio in municipal district Las Marias, department of Mayaguez. Population 1.143.

Palmar; barrio in municipal district Aguadilla, department of Aguadilla. Population 700.

Palmarejo; barrio in municipal district Coamo, department of Ponce.

Palmarejo; barrio in municipal district Corozal, department of Bayamon. Population 901.

Palmarejo; barrio in municipal district Lajas, department of Mayaguez.

Palmarito; barrio in municipal district Corozal, department of Bayamon. Population 770.

Palmareta, Cerro; hills in department of Guayama.

Palmas; barrio in municipal district Arroyo, department of Guayama.

Palmas; barrio in municipal district Bayamon, department of Bayamon. Population 406.

Palmas; barrio in municipal district Guayama. department of Guayama. Population 1,200.

Palmas Altas; barrio in municipal district Barceloneta, department of Arecibo. Population 1,259.

Palmas Altas, Punta de; point on northern shore, near Barceloneta.

Palo Blanco, Quebrada: small stream on north coast, near Quebradillas.

Palo de Cafe, Cerro; hills in southeastern part of department of Arecibo.

Palo Incado, Cerro; hills near Coamo.

Palo Lincado; barrio in municipal district Barranquitas, department of Ponce. Population 1,299.

Palomas; barrio in municipal district Comerio, department of Guayama. Population 1,091.

Palominos, Isla; island off eastern coast.

Palos Blancos; barrio in municipal district Corozal, department of Bayamon. Population 1,367.

Palo Seco; barrio in municipal district Maunabo, department of Humacao. Population 802.

Palo Seco, Punta; point on western entrance of harbor of San Juan, on northern coast.

Palo Seco, Punta de; point on southern coast near Santa Isabel.

Palo Seco, Ensenada de; harbor on southern coast near Santa Isabel.

Pardras, Ensenada las; harbor on southern coast near Guanica.

Parguera; barrio in municipal district Lajas, department of Mayaguez.

Parguera, Isla; islet off southern coast, west of Ponce.

Paris; barrio in municipal district Lajas, department of Mayaguez. Population 875.

Paso Palma; barrio in municipal district Utuado, department of Arecibo. Population 1,317.

Pastillo, Punta del; point on southern coast.

Pastillo, Puerto del; roadstead on southern coast.

Pasto; barrio in municipal district Coamo, department of Ponce. Population 1,272.

Pasto; barrio in municipal district Guayanilla, department of Ponce. Population 1,276.

Pasto; barrio in municipal district Morovis, department of Arecibo. Population 1,314.

Pastos; barrio in municipal district Aibonito, department of Ponce.

Pasto, Sierra del; mountains in western part of department of Ponce.

Pasto Viejo; barrio in municipal district Cayey, department of Guyama.

Pasto Viejo, Cerro; hills in eastern part of department of Ponce.

Patillas; municipal district in department of Humacao. Area 64 square miles. Population 11,168.

Patillas; city and post-office near coast in department of Humacao. Population 1,590.

Patillas, Puerto del; harbor on southeastern coast.

Patillas, Rio Grande de; a stream in the southeastern part of the island.

Pedernales; barrio in municipal district Cabo Rojo, department of Mayaguez. Population 2,060.

Pedro Avila; barrio in municipal district Cayey, department of Guayama.

Pedro Garcia; barrio in municipal district Coamo, department of Ponce. Population 1,697.

Peladas, Cerro; hills in northern part of Mayaguez department.

Pelado, Cerro; mountains in department of Guayama.

Pellejas; barrio in municipal district Adjuntas, department of Ponce. Population 1,521.

Pellejas; barrio in municipal district Barros, department of Ponce.

Pellejas, Rio; a right-hand branch of Arecibo River in department of Arecibo.

Peña Agujereda; point on northwestern coast in department of Aguadilla.

Peña Jacinto; point on northwest coast in department of Aguadilla.

Peña Montones; point on northwest coast in department of Aguadilla.

Peña Pobre; barrio in municipal district Naguabo, department of Humacao. Population 1,064.

Peñones, Cuchilla de las; mountains in Fajardo district.

Peñuelas; municipal district in department of Ponce. Area 48 square miles. Population 12,129.

Peñuelas; interior city and post-office in department of Ponce. Population 1,129.

Percha; barrio in municipal district Morovis, department of Arecibo. Population 1,124.

Percha, Punta de la; point on northeast coast near Luquillo.

Perchas Nos. 1 and 2; barrios in municipal district San Sebastian, department of Aguadilla.

Pesa; barrio in municipal district Ciales, department of Arecibo. Population 994.

Pescadores, Punta; point at entrance to Puerto Guanica, on southern coast.

Petrona, Punta; point on south coast near Santa Isabel.

Pezuela; barrio in municipal district Lares, department of Aguadilla. Population 1,010.

Picua, Punta; point on northeastern coast near Rio Grande.

Picua, Punta; point on southern coast near Guanica.

Piedra; barrio in municipal district Cayey, department of Guayama.

Piedra Gorda; barrio in municipal district Camuy, department of Arecibo. Population 895.

Piedras; municipal district in department of Humacao. Area 43 square miles. Population 8,602.

Piedras Blancas; barrio in municipal district San Sebastian, department of Aguadilla.

Piedras Blancas; barrio in municipal district Aguada, department of Aguadilla.

Piedras, Rio; a small stream flowing into San Juan Harbor.

Piletas; barrio in municipal district Lares, department of Aguadilla. Population 2,455.

Pimentol, Cerro; hills in southern part of department of Ponce.

Piñales; barrio in municipal district Añasco, department of Mayaguez. Population 1,038.

Piñales; hills in northern part of Mayaguez department.

Piñas; barrio in municipal district Comerio, department of Guayama.

Piñas; barrio in municipal district Toa Alta, department of Bayamon. Population 841.

Piñas, Montanes de las; mountains near Cidra.

Piñeiro, Punta; point on Isla Puerca, off eastern coast.

Piñeiro, Isla; island off eastern coast.

Pitahaya; barrio in municipal district Arroyo, department of Guayama. Population 801.

Pitahaya; barrio in municipal district Fajardo, department of Humacao. Population 1,103.

Pitajalla, Cerro; hills in eastern part of department of Bayamon.

Pitajalla, Rio: a small stream in the northeastern part of the island.

Pitajaya, Punta; point on southwest coast.

Planas; barrio in municipal district Isabela, department of Aguadilla. Population 936.

Plata; barrio in municipal district Aibonito, department of Ponce. Population 1,554.

Plata; barrio in municipal district Lajas, department of Mayaguez.

Plata; barrio in municipal district Moca, department of Aguadilla. Population 663.

Plata, Rio de la; a river heading in the main range and flowing north through Bayamon department to its mouth near Dorado. Length 43 miles.

Playa; barrio in municipal district Añasco, department of Mayaguez.

Playa; barrio in municipal district Humacao, department of Humacao. Populalation 646.

Playa; barrio in municipal district Guayanilla, department of Ponce.

Playa; barrio in municipal district Ponce, department of Ponce. Population 4,660.

Playa; barrio in municipal district Santa Isabela, department of Ponce.

Playa: barrio in municipal district Yabucoa, department of Humacao. Population 1,016.

Playa Sucia, Enseñada; harbor near southwest point.

Pollos; barrio in municipal district Patillas, department of Humacao.

Ponce; a department occupying much of the southern portion of the island. It is the largest of the departments, its area being 821 square miles. The population is the greatest—203,191. The density of population is 247 per square mile. As to race, the department is divided in the proportions of 59.6 per cent white and 40.4 per cent colored. Of the total area, 22 per cent, or more than one-fifth, is under cultivation. The principal crop is coffee, in which 43 per cent of the cultivated area is planted, while in sugar cane there is only 15 per cent. Of the total farm area, 94 per cent was owned by its occupants, only 6 per cent being rented.

Ponce; municipal district in department of Ponce. Area 143 square miles. Population 55,477.

Ponce; coast city and post-office in department of Ponce. Population 27,952.

Ponce, Puerto; harbor on southern coast.

Portillo; barrio in municipal district Adjuntas, department of Ponce. Population 1,271.

Portugues; barrio in municipal district Adjuntas, department of Ponce.

Portugues; barrio in municipal district Ponce, department of Ponce. Population 1,050.

Portugues, Rio; a small stream in the southern part of the island.

Pozuelo, Punta; point on southern coast.

Pozas; barrio in municipal district Ciales, department of Arecibo. P 2,796.

Pozas; barrio in municipal district San Sebastian, department of Aguad

Pozo-Hondo; barrio in municipal district Guayama, department of Gu

Pozos, Pena de los; point on northwest coast in department of Aguadil

Prieto, Rio; a left-hand branch of Rio Blanco, in the northwest.

Puente; barrio in municipal district Camuy, department of Arecibo. P 718.

Puerca, Isla; island off eastern coast.

Puerca, Isla; island off southern coast.

Puerto Diablo; barrio in municipal district Vieques, department of Hu

Puerto Ferro; barrio in municipal district Vieques, department of Hum

Puerto Nuevo; barrio in municipal district Vega Baja, department of Population 706.

Puerto Nuevo, Bahia de; inner harbor of San Juan on north coast.

Puerto Nuevo, Punta de; point on eastern side of Puerto Nuevo on coast.

Puerto Nuevo, Rio; a small stream flowing into San Juan Harbor.

Puerto Real Abajo; barrio in municipal district Vieques, department cao. Population 636.

Puerto Real Arriba; barrio in municipal district Vieques, department cao. Population 708.

Puertos; barrio in municipal district Camuy, department of Arecibo. tion 419.

Pugnado Adentro; barrio in municipal district Vega Baja, department mon. Population 425.

Pugnado Afuera; barrio in municipal district Vega Baja, department mon. Population 1,336.

Pulguillas; barrio in municipal district Coamo, department of Ponce. tion 1,142.

Punta Arenas; barrio in municipal district Vieques, department of Hun

Punta Santiago; post village in department of Humacao.

Puntas; barrio in municipal district Rincon, department of Aguadilla. tion, 1,006.

Puntas, Cerro de; mountains in northern part of department of Ponce.

Puntilla, Punta de la; point on southern coast, near Guayanilla.

Purisima Concepcion; barrio in municipal district Las Marias, depart Mayaguez. Population 1,007.

Quebrada; barrio in municipal district Camuy, department of Arecibo. tion 1,213.

Quebrada; barrio in municipal district San Lorenzo, department of Gu Population 1,193.

Quebrada Arená; barrio in municipal district San Lorenzo, departm Guayama. Population 1,452.

Quebrada Arenas; barrio in municipal district Maunabo, department of Hu

Quebrada Arenas; barrio in municipal district Piedras, department of Hu

Quebrada Arenas; barrio in municipal district Rio Piedras, department of mon. Population 716.

Quebrada Arenas; barrio in municipal district Toa Alta, department of mon. Population 777.

Quebrada Arenas; barrio in municipal district Vega Baja, department of mon. Population 348.

Quebrada Arriba; barrio in municipal district Cayey, department of Gua

Quebrada Arriba; barrio in municipal district Patillas, department of Hu

Quebrada Ceiba; barrio in municipal district Penuelas, department of Ponce. Population 1,006.

Quebrada Cruz; barrio in municipal district Toa Alta, department of Bayamon. Population 1,165.

Quebrada Fajardo; barrio in municipal district Fajardo, department of Humacao. Population 888.

Quebrada Grande; barrio in municipal district Barranquitas, department of Ponce. Population 931.

Quebrada Grande; barrio in municipal district Mayaguez, department of Mayaguez. Population 1,035.

Quebrada Grande; barrio in municipal district Trujillo Alto, department of Bayamon. Population 955.

Quebrada Honda; barrio in municipal district Guayanilla, department of Ponce,

Quebrada Honda; barrio in municipal district San Lorenzo, department of Guayama. Population 1,616.

Quebrada Honda, Punta; point on southeast coast.

Quebrada Infierno; barrio in municipal district Gurabo, department of Guayama.

Quebrada Infierno; barrio in municipal district Trujillo Alto, department of Bayamon. Population 1,487.

Quebrada Larga; barrio in municipal district Añasco, department of Mayaguez.

Quebrada Limon; barrio in municipal district of Ponce, department of Ponce. Population 547.

Quebradas; barrio in municipal district Guayanilla, department of Ponce.

Quebradas; barrio in municipal district Yauco, department of Ponce. Population 1,009.

Quebrada Seca; barrio in municipal district Fajardo, department of Humacao.

Quebrada Yeguas; barrio in municipal district Salinas, department of Guayama.

Quebradillas; municipal district in department of Arecibo. Area 19 square miles. Population 7,432.

Quebradillas; city and post-office in department of Arecibo. Population 1,166.

Quebradillas; barrio in municipal district Barranquitas, department of Ponce. Population 1,051.

Quebradillas; barrio in municipal district Quebradillas, department of Arecibo. Population 1,166.

Quemado; barrio in municipal district Mayaguez, department of Mayaguez. Population 952.

Quemado; barrio in municipal district San Lorenzo, department of Guayama. Population 1,255.

Rabanal; barrio in municipal district Cidra, department of Guayama.

Ramos, Isla; island off eastern coast, near Fajardo.

Rancheras; barrio in municipal district Yauco, department of Ponce. Population 1,220.

Raspado, Cerro; hills in the southeastern part of the department of Ponce.

Ratones, Isla; island off southern coast, near Salinas.

Rayo; barrio in municipal district Sabana Grande, department of Mayaguez. Population 1,222.

Real; barrio in municipal district Ponce, department of Ponce. Population 1,440.

Real, Cayo; islet off southern coast, near Ponce.

Real, Puerto; harbor on western coast.

Redonda, Piedra; rocky point on north coast, near Quebradillas.

Redondo, Cayo; islet off southern coast.

Retiro; barrio in municipal district San German, department of Mayaguez. Population 983.

Rincon; municipal district in department of Aguadilla. Area 21 square miles; population 6,641.

Rincon; coast city and post-office in department of Aguadilla. Population 1,074.

Rincon; barrio in municipal district Cayey, department of Guayama.

Rincon; barrio in municipal district Cidra, department of Guayama.

Rincon; barrio in municipal district Gurabo, department of Guayama. Population 1,155.

Rincon; barrio in municipal district Sabana Grande, department of Mayaguez. Population 1,244.

Rincon, Ensenada de; roadstead on southern coast.

Rio; barrio in municipal district Mayaguez, department of Mayaguez. Population 1,722.

Rio; barrio in municipal district Naguabo, department of Humacao.

Rio; barrio in municipal district Rio Piedras, department of Bayamon. Population 651.

Rio Abajo; barrio in municipal district Cidra, department of Guayama.

Rio Abajo; barrio in municipal district Humacao, department of Humacao.

Rio Abajo; barrio in municipal district Fajardo, department of Humacao. Population 1,021.

Rio Abajo; barrio in municipal district Piedras, department of Humacao. Population 1,122.

Rio Abajo; barrio in municipal district Utuado, department of Arecibo. Population 1,285.

Rio Abajo; barrio in municipal district Vega Baja, department of Bayamen.

Rio Arriba; barrio in municipal district Fajardo, department of Humacao. Population 726.

Rio Arriba; barrio in municipal district Piedras, department of Humacao. Population 1,028.

Rio Arriba; barrio in municipal district Vega Baja, department of Bayamon.

Rio Arriba; barrio in municipal district Añasco, department of Mayaguez.

Rio Arriba; barrio in municipal district Arecibo, department of Arecibo. Population 1,709.

Rio Arriba; barrio in municipal district Patillas, department of Humacao. Population 1,080.

Rio Arriba Poniente; barrio in municipal district Manati, department of Arecibo. Population 1,862.

Rio Arriba Saliente; barrio in municipal district Manati, department of Arecibo. Population 1,593.

Rio Blanco Abajo; barrio in municipal district Naguabo, department of Humacao. Population 976.

Rio Blanco Arriba; barrio in municipal district Naguabo, department of Humacao. Population 959.

Rio Cañas; barrio in municipal district Añasco, department of Mayaguez.

Rio Cañas; barrio in municipal district Caguas, department of Guayama. Population 1,336.

Rio Cañas; barrio in municipal district Las Marias, department of Mayaguez. Population 772.

Rio Cañas Abajo; barrio in municipal district Juana Diaz, department of Ponce. Population 1,066.

Rio Cañas Abajo; barrio in municipal district Mayaguez, department of Mayaguez. Population 1,095.

Rio Cañas Arriba; barrio in municipal district Juana Diaz, department of Ponce. Population 990.

Rio Cañas Arriba; barrio in municipal district Mayaguez, department of Mayaguez.

Rio Grande; municipal district in department of Bayamon. Area 47 square miles. Population 12,365.

Rio Grande; interior city and post-office in department of Bayamon. Population 1,285.

Rio Grande; barrio in municipal district Morovis, department of Arecibo. Population 841.

Rio Grande; barrio in municipal district Rincon, department of Aguadilla. Population 676.

Rio Grande; barrio in municipal district Aguada, department of Aguadilla.

Rio Hondo; barrio in municipal district Comerio, department of Guayama. Population 1,161.

Rio Hondo; barrio in municipal district Mayaguez, department of Mayaguez.

Rio, Isla del; islet off southern coast.

Rio Jueyes; barrio in municipal district Salinas, department of Guayama. Population 1,248.

Rio Lajas; barrio in municipal district Dorado, department of Bayamon. Population 377.

Rio Lajas; barrio in municipal district Toa Alta, department of Bayamon. Population 973.

Rio Piedras; municipal district in the department of Bayamon. Area 52 square miles. Population 13,760.

Rio Piedras; interior city and post-office in department of Bayamon. Population 2,249.

Rio Prieto; barrio in municipal district Lares, department of Aguadilla. Population 1,931.

Rio Prieto; barrio in municipal district Yauco, department of Ponce. Population 799.

Rios; barrio in municipal district Patillas, department of Humacao.

Roadero, Cerro; mountains in western part of department of Ponce.

Roble; barrio in municipal district Aibonito, department of Ponce.

Robles; barrio in municipal district San Sebastian, department of Aguadilla.

Rocha; barrio in municipal district Moca, department of Aguadilla. Population 902.

Rodeo, Punta; point on southern coast.

Rojo, Cabo; the southwestern cape of the island.

Roncador; barrio in municipal district Utuado, department of Arecibo. Population 1,130.

Rosario; barrio in municipal district Aguada, department of Aguadilla.

Rosario; barrio in municipal district Mayaguez, department of Mayaguez. Population 852.

Rosario Alto; barrio in municipal district San German, department of Mayaguez. Population 811.

Rosario Baja; barrio in municipal district San German, department of Mayaguez. Population 1,027.

Rosario Peñon; barrio in municipal district San German, department of Mayaguez.

Rosario, Rio del; a right-hand branch of Rio Guanajibo, in the western part of the island.

Rubias; barrio in municipal district Yauco, department of Ponce. Population 627.

Rucio; barrio in municipal district Peñuelas, department of Ponce. Population 2,233.

Sabalos; barrio in municipal district Mayaguez, department of Mayaguez. Population 2,365.

Sabana; barrio in municipal district Barros, department of Ponce.

Sabana; barrio in municipal district Fajardo, department of Humacao.

Sabana; barrio in municipal district Rio Grande, department of Bayamon. Population 600.

Sabana; barrio in municipal district Vega Alta, department of Bayamon. Population 910.

Sabana, Cerro; mountains in Humacao department.

Sabana, Rio; a small stream in the northeastern part, flowing into the sea at Luquillo.

Sabana Abaja; barrio in municipal district Carolina, department of Bayamon. Population 578.

Sabana Eneas; barrio in municipal district San German, department of Mayaguez.

Sabana Grande; municipal district in department of Mayaguez. Area 55 square miles. Population 10,560.

Sabana Grande; interior city and post-office in department of Mayaguez. Population 2,581.

Sabana Grande; barrio in municipal district Utuado, department of Arecibo. Population 1,053.

Sabana Grande Abajo; barrio in municipal district San German, department of Mayaguez. Population 1,091.

Sabana Hoyos; barrio in municipal district Arecibo, department of Arecibo. Population 3,568.

Sabana Llana; barrio in municipal district Juana Diaz, department of Ponce.

Sabana Llana; barrio in municipal district Rio Piedras, department of Bayamon. Population 1,644.

Sabana Seca; barrio in municipal district Toa Baja, department of Bayamon. Population 787.

Sabana Yeguas; barrio in municipal district Lajas, department of Mayaguez. Population 938.

Sabanetas; barrio in municipal district Mayaguez, department of Mayaguez. Population 1,401.

Sabanetas; barrio in municipal district Ponce, department of Ponce. Population 1,065.

Saco; barrio in municipal district Fajardo, department of Humacao.

Salinas; municipal district in department of Guayama. Area 98 square miles. Population 5,731.

Salinas; coast city and post-office in department of Guayama. Population, 1,192.

Salinas, Punta de; point on north coast west of San Juan.

Salinas, Puerto de; harbor on southern coast.

Salinas, Punta; point on southern coast, near Ponce.

Saltillo; barrio in municipal district Adjuntas, department of Ponce. Population 2,098.

Salto; barrio in municipal district Cidra, department of Guayama.

Salto; barrio in municipal district San Sebastian, department of Aguadilla.

Salto Abajo; barrio in municipal district Utuado, department of Arecibo. Population 836.

Salto Arriba; barrio in municipal district Utuado, department of Arecibo. Population 855.

Saltos; barrio in municipal district Barros, department of Ponce. Population 1,037.

Salud; barrio in municipal district Mayaguez, department of Mayaguez. Population 1,726.

San Anton; barrio in municipal district Ponce, department of Ponce. Population 963.

San Antonio; barrio in municipal district Caguas, department of Guayama. Population 887.

San Antonio; barrio in municipal district Carolina, department of Bayamon. Population 615.

San Antonio; barrio in municipal district Quebradillas, department of Arecibo. Population 1,760.

San Cristobal; barrio in municipal district San Juan, department of Bayamon. Population 3,131.

San Diego, Punta de; point on northeastern coast.

San Domingo, Cerro de; mountains in department of Ponce.

San Francisco; barrio in municipal district Humacao, department of Humacao.

San Francisco; barrio in municipal district San Juan, department of Bayamon. Population 1,177.

San German; municipal district in department of Mayaguez. Area 55 square miles. Population 20,246.

San German; interior city and post-office in department of Mayaguez. Population 3,954.

San Ildefonso; barrio in municipal district Coamo, department of Ponce. Population 1,252.

San Juan; municipal district, coast city, and capital of the island in department of Bayamon. Area 12 square miles. Population 32,048.

San Juan; barrio in municipal district Humacao, department of Humacao. Population 1,169.

San Jose; barrio in municipal district Quebradillas, department of Arecibo. Population 687.

San Juan, Bahia de; harbor of San Juan on northern coast.

San Jose, Laguna; lagoon on north coast east of San Juan.

San Lorenzo; municipal district in department of Guayama. Area 54 square miles. Population 13,433.

San Lorenzo; interior city and post-office in department of Guayama. Population 2,084.

San Lorenzo; barrio in municipal district Morovis, department of Arecibo. Population 884.

San Salvador; barrio in municipal district Caguas, department of Guayama. Population 1,605.

San Patricio; barrio in municipal district Ponce, department of Ponce. Population 1,217.

San Sebastian; municipal district in department of Aguadilla. Area 43 square miles. Population 16,412.

San Sebastian; interior city and post-office in department of Aguadilla. Population 1,700.

Santa Ana, Cerro; hills near Hato Grande.

Santa Barbara; barrio in municipal district Aguadilla, department of Aguadilla. Population 1,502.

Santa Catalina; barrio in municipal district Coamo, department of Ponce. Population 1,864.

Santa Cruz; barrio in municipal district Carolina, department of Bayamon. Population 435.

Santo Domingo; barrio in municipal district Humacao, department of Humacao. Population 1,505.

Santo Domingo; barrio in municipal district Peñuelas, department of Ponce. Population 812.

Santa Isabel; municipal district in department of Ponce. Area 44 square miles. Population 4,858.

Santa Isabel; coast city and post-office in department of Ponce. Population 1,142.

Santa Isabel; barrio in municipal district Utuado, department of Arecibo. Population 875.

Santana; barrio in municipal district Arecibo, department of Arecibo. Population 1,555.

Santana; barrio in municipal district Sabana Grande, department of Mayaguez. Population 921.

Santa Olaya; barrio in municipal district Bayamon, department of Bayamon. Population 1,100.

Santa Rosa; barrio in municipal district Bayamon, department of Bayamon. Population, 687.

Santa Rosa; barrio in municipal district Lajas, department of Mayaguez.

Santa Rosa; barrio in municipal district Utuado, department of Arecibo. Population 793.

Santa Teresa, Cerro; mountains in department of Humacao.

Santiago; barrio in municipal district Camuy, department of Arecibo. Population 657.

Santiago; barrio in municipal district Humacao, department of Humacao.

Santiago, Cayo; small island off southeastern coast.

Santiago Luna; barrio in municipal district Naguabo, department of Humacao.

Santiago, Punta de; point on southeast coast near Humacao.

Santiago, Rio; a small stream in the eastern part of the island.

Santurce; barrio in municipal district San Juan, department of Bayamon. Population 5,840.

Sardinera; barrio in municipal district Fajardo, department of Humacao.

Sardinera, Punta; point on north coast near Dorado.

Sendas, Altos de; hills in southern part of department of Arecibo.

Sierra Alta; barrio in municipal district Yauco, department of Ponce. Population 1,411.

Sierra Baja; barrio in municipal district Guayanilla, department of Ponce. Population 787.

Sombrero, Cerro; hills near Maunabo.

Sonador; barrio in municipal district San Sebastian, department of Aguadilla.

Sonador, Rio; a left-hand branch of Rio Culebrinas, in the northwestern part of the island.

Sonadora; barrio in municipal district Aguas Buenas, department of Guayama.

Sonadora; barrio in municipal district Bayamon, department of Bayamon. Population 729.

Sonadora, Cerro; hills in department of Guayama.

Sumidero; barrio in municipal district Aguas Buenas, department of Guayama. Population 984.

Sumido; barrio in municipal district Cayey, department of Guayama.

Sumido, Cerro; hills near Cayey.

Sur; barrio in municipal district Cidra, department of Guayama.

Susua; barrio in municipal district Sabana Grande, department of Mayaguez.

Susua, Rio; a river in the southwestern part of the island.

Tabonuco; barrio in municipal district Sabana Grande, department of Mayaguez. Population 1,888.

Tacones, Punta; point on north coast at mouth of the River Bayamon.

Talante; barrio in municipal district Maunabo, department of Humacao.

Tallaboa; post village in department of Ponce.

Tallaboa Alta; barrio in municipal district Peñuelas, department of Ponce. Population 946.

Tallaboa, Puerto de; roadstead on southern coast.

Tallaboa, Rio; a stream in the southern part of the island.

Tallaboa Poniente; barrio in municipal district Peñuelas, department of Ponce. Population 874.

Tallaboa Saliente; barrio in municipal district Peñuelas, department of Ponce.

Tamarinde; barrio in municipal district Aguadilla, department of Aguadilla. Population 1,630.

Tanama· barrio in municipal district Arecibo. department of Arecibo. Population, 1.023.

Tanama; barrio in municipal district Adjuntas, department of Ponce. Population 752.

Tanama, Rio; a left-hand branch of Arecibo River in department of Arecibo.

Teatro; barrio in municipal district San Juan, department of Bayamon. Population 2,592.

Teja; barrio in municipal district Yabucoa, department of Humacao. Population 933.

Tejas; barrio in municipal district Humacao, department of Humacao. Population 704.

Tejas Alto; barrio in municipal district Piedras, department of Humacao. Population 948.

Tejon, Cerro; hills in Mayaguez district.

Terranova; barrio in municipal district Quebradillas, department of Arecibo. Population 779.

Tetuan; barrio in municipal district Utuado. department of Arecibo. Population 1,678.

Tibes; barrio in municipal district Ponce, department of Ponce. Population 1,878.

Tierras Nuevas Poniente; barrio in municipal district Manati, department of Arecibo. Population 1,534.

Tierras Nuevas Saliente; barrio in municipal district Manati, department of Arecibo. Population 776.

Tijera, Cerro de la: hills near Juana Diaz.

Tijeras; barrio in municipal district Juana Diaz, department of Ponce.

Tinaja, Punta; point on southwest coast.

Toa Alta; municipal district in department of Bayamon. Area 22 square miles. Population 7,908.

Toa Alta; post village in department of Bayamon.

Toa, Bahia de; bay on north coast west of San Juan.

Toa Baja; municipal district in department of Bayamon. Area 43 square miles. Population 4,030.

Toa Baja; city and post-office near coast in department of Bayamon. Population 1,300.

Toa Vaca, Rio de; a branch of Rio Jacaguas in the southern part.

Toconies, Punta; point on southwestern coast.

Toita; barrio in municipal district Cayey, department of Guayama.

Toita; barrio in municipal district Cidra, department of Guayama.

Tomas de Castro; barrio in municipal district Caguas, department of Guayama. Population 1,575.

Toro Negro; barrio in municipal district Ciales, department of Arecibo. Population 2,252.

Toro Negro, Rio; a branch of Manati River in department of Arecibo.

Toro, El; summit in eastern part of department of Bayamon.

Toro, Punta del; point on southeastern coast.

Toro, Quebrada del; small stream on northern coast near Quebradillas.

Torre; barrio in municipal district Sabana Grande, department of Mayaguez.

Torrecilla; barrio in municipal district Morovis, department of Arecibo. Population 572.

Torrecilla, Laguna; lagoon on northern coast east of San Juan.

Tumbado, Cerro: hills near Maunabo.

Tuna: barrio in municipal district San German, depar

Turabo: barrio in municipal district Caguas, departme
lation 1,557.

Unibon: barrio in municipal district Morovis, depart
tion 643.

Urrejola: barrio in municipal district San Sebastian, d

Usabon, Rio: a left-hand branch of Rio de la Plata.

Utuado: municipal district in department of Arecibo.
Population 43,860.

Utuado: interior city and post-office in department of A

Uvero, Punta del: point on northern coast near Loiza.

Vacas: barrio in municipal district Juana Diaz, depar
tion 1,841.

Vaciatalegas, Punta: point on north coast near Loiza.

Vaga: barrio in municipal district Morovis, departmen
828.

Valenciano Abajo: barrio in municipal district Juncos.

Valenciano Arriba: barrio in municipal district Jun
ama.

Valencianos, Rio: a right-hand tributary to Loiza Riv

Vaguera, Punta: point on southern coast near Guanic

Vega: barrio in municipal district Cayey, department

Vega: barrio in municipal district Comerio, departmen

Vega Abajo: barrio in municipal district Adjuntas, de

Vega Alta: municipal district in department of Bayam
Population 6,107.

Vega Alta: interior city and post-office in department
1,081.

Vega Arriba: barrio in municipal district Adjunta
Population 1,159.

Vega Baja: municipal district in department of Bayam
Population, 10,305.

Vieques: island and municipal district in department of Humacao east of Porto Rico. Area 79 square miles. Population 6,642.

Vieques; city and post-office in department of Humacao. Population 2,646.

Viera Quebrada; ravine on north coast, near Quebradillas.

Vigia de Coamo, Cerro; hills near Coamo, in department of Ponce.

Vijia, Cerro; hills in Rincon district.

Villalba Abajo; barrio in municipal district Juana Diaz, department of Ponce. Population 1,363.

Villalba Arriba; barrio in municipal district Juana Diaz, department of Ponce. Population 2,917.

Viva Abajo; barrio in municipal district Utuado, department of Arecibo. Population 1,253.

Viva Arriba; barrio in municipal district Utuado, department of Arecibo. Population 1,240.

Vivi, Rio; a right-hand branch of Arecibo River in department of Arecibo.

Voladoras; barrio in municipal district Moca, department of Aguadilla. Population 1,267.

Yabucoa; municipal district in department of Humacao. Area 45 square miles. Population 13,905.

Yabucoa; interior city and post-office in department of Humacao. Population 1,838.

Yabucoa, Puerto de; harbor on southeastern coast.

Yabueca, Altos de; mountain summits in northwestern part of department of Ponce.

Yagua, Cerro; mountains in Mayaguez department.

Yaguez, Rio; a small stream flowing into the sea near Mayaguez on the west coast.

Yahuecas; barrio in municipal district Adjuntas, department of Ponce. Population 1,710.

Yauco; municipal district in department of Ponce. Area 102 square miles. Population 27,119.

Yauco; interior city and post-office in department of Ponce. Population 6,108.

Yayales; barrio in municipal district Adjuntas, department of Ponce. Population 660.

Yeguada; barrio in municipal district Camuy, department of Arecibo. Population 794.

Yeguada; barrio in municipal district Vega Baja, department of Bayamon. Population 428.

Yeguadilla Occidental; barrio in municipal district Hatillo, department of Arecibo. Population 963.

Yeguadilla Oriental; barrio in municipal district Hatillo, department of Arecibo. Population 995.

Yeguas, Punta de las; point on southeastern coast.

Yunes, Rio; a right-hand tributary of Arecibo River, in Arecibo department.

Yunque, El; the highest summit of the island in Sierra Luquillo, in the northeastern part. Elevation 3,790.

Zafao, Cerro del; mountains in the northwestern part of department of Ponce.

Zancudos, Isla; island off eastern coast.

Zanja; barrio in municipal district Camuy, department of Arecibo. Population 833.

Zanja Colorada Playa; beach on north coast near Arecibo.

Zarzal; barrio in municipal district Rio Grande, department of Bayamon. Population 1,191.

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[Bulletin No. 183.]

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